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PRACTICAL
LABORATORY COURSE
IN
MEDICAL CHEMISTRY
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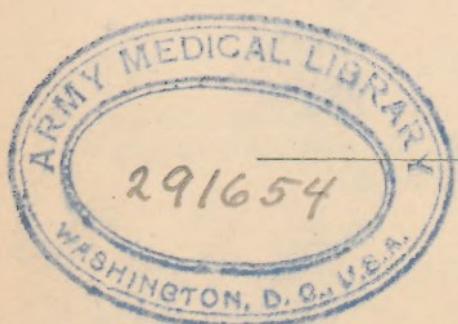
IN

MEDICAL CHEMISTRY

BY

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OF THE CITY OF NEW YORK



NEW YORK
WILLIAM WOOD & COMPANY
56 & 58 LAFAYETTE PLACE

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201-213 East 12th Street
NEW YORK

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MEDICAL CHEMISTRY.

INTRODUCTION.

1. It is the object of the following course to give to medical students sufficient practice in chemical manipulation to enable them to perform in a satisfactory and reliable manner those tests which are required of the practising physician, and also to give them some experience in the use of chemical symbols, formulæ, and equations.

The time of the medical student is so occupied during a regular college session by the numerous branches he is required to study, that only a few hours are available for practical chemistry. These we have endeavored to utilize to the best advantage. The laboratory course is, therefore, confined to instruction in manipulation and to the study of tests which are useful in forming a correct diagnosis, or in solving hygienic problems. The more extended operations required to make a toxicological examination and the greater experience and knowledge necessary to defend the same in court should always lead the physician to transfer these examinations to a chemical expert.

Every other page is left blank in order that the student may record in its proper place the results of the experiments he makes and of additional facts obtained from oral instruction. The experiments to be performed by the student have been put in large type. Quantities are indicated by the signs employed in writing prescriptions, the object being to give students practice in their use.

GENERAL MANIPULATION.

2. The following methods of manipulation especially command our attention: 1st, solution; 2d, decantation and filtration; 3d, evaporation or desiccation; 4th, distillation; 5th, incineration.

SOLUTION.

3. A leading condition for the action of substances on each other is that one or both shall be in the liquid state. This may be accomplished in three ways: 1st, by solvents which impart the required state without changing the properties of the substance—this we may call simple solution; 2d, by fusion or melting, which also leaves the properties unchanged, and 3d, by decomposition by acids, or in other ways; the properties in this case undergo great changes. The first of these requires further explanation.

SIMPLE SOLUTION AND SOLVENTS.

4. The solvents generally employed are water, alcohol, ether, chloroform, and bisulphide of carbon. Unless otherwise stated, water is understood to be the menstruum.

First.—The solution is prepared by the action of cold water upon the substance. In the case of organic bodies, as the different kinds of bark; this is known as a *cold infusion*, *e.g.*, wild cherry bark infusion.

Second.—Boiling water is poured upon the substance; this is technically known as a *hot infusion*, *e.g.*, tea.

Third.—The substance is boiled with water for some time; this is called a *decoction*, *e.g.*, litmus water.

Fourth.—When alcohol is used as the solvent, the preparation is commonly called a *tincture*.

DECANTATION AND FILTRATION.

5. The action of the solvent having been promoted by agitation, the undissolved portions are allowed to settle, when the clear solution is carefully poured off; this is called *decantation*.

The operation of pouring without loss may be conducted by holding a solid glass rod vertically against the lip of the vessel from which the liquid is passing. It thus guides the fluid into the other vessel and prevents it from running down the side of that from which it is poured.

For the complete separation of dissolved from undissolved matter, *filtration* must be employed. An unsized paper, called filter paper, is prepared for this purpose. It should be cut into circles of various sizes; a very convenient size is three inches in diameter.

Taking one of these circles, fold it exactly in two, then fold it again exactly at right angles to the first folding; it is now in four layers. Open it out, holding three of the layers together, and a conical cup is formed. Set this in a funnel of suitable size, moisten the paper with a little water, stand the funnel stem down in a test-tube, or flask, and the filter is ready.

Pour into the paper cup the mixture to be operated upon; the fluid passes through, and the insoluble matter remains in the cup. Wash the solid contents of the filter or cup with water or other menstruum employed until all soluble portions are removed.

EVAPORATION OR DESICCATION

6. Is employed for the separation of a solid substance from the fluid in which it is dissolved. For this purpose shallow porcelain dishes, or watch-glasses, are used. The large extent of surface of these vessels promotes the escape of the vapor. Heat may be applied either directly to the vessel, or it may be placed on a water-bath, and the temperature thus kept below 212° F., or 100° C.

The hot-air oven is a double vessel. The space between the two walls being filled with water, the temperature is raised to any required degree below 212° F., as indicated by a thermometer placed therein. The substance to be dried is placed in the inner vessel through which air passes.

Where the desiccation is to be accomplished at a very low temperature, it is conducted over strong sulphuric acid in an air-pump vacuum.

DISTILLATION

7. Is employed for the more or less complete separation of a volatile from a less volatile liquid, *e.g.*, alcohol from water. The apparatus required is a retort, or other vessel in which evaporation may be conducted either directly, or by the water-bath; and a flask, or other form of condenser, in which the vapor may be cooled and forced to reassume the liquid state. This process must be resorted to in the detection of the volatile poisons, like alcohol, hydrocyanic acid, etc.

INCINERATION

8. Is employed to separate non-volatile inorganic substances from those which are organic or volatile. It is generally conducted in a capsule or spoon made of platinum; very few substances act upon this metal, and it can withstand a very high temperature. For the practical application of this process, see article 12.

CHEMICAL DIVISIONS OF SUBSTANCES.

9. Three kinds of subdivision of bodies are used in chemistry; 1, element and compound; 2, inorganic and organic; 3, base, acid, and salt. For the proper study of the subject our ideas regarding these and certain other terms must be as exact as possible.

ELEMENT AND COMPOUND WITH DEFINITIONS.

10. *An element or radical* is a body which has not yet been decomposed, *e.g.*, oxygen, carbon.

A compound is a body made up of two or more elements in definite proportions, *e.g.*, carbonic acid gas.

An atom is the smallest conceivable subdivision of an element.

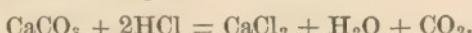
A molecule is composed of two or more atoms; it is the smallest quantity of an element, or of a compound, that can exist in the free state.

A compound radical is a compound body which acts like an element in forming compounds. Sometimes it may exist in the free state, *e.g.*, cyanogen. In other cases it cannot exist free, *e.g.*, ammonium; it is then called a *hypothetical radical*.

A symbol is a sign used to indicate the presence of an element. It is either the initial capital or the first and an additional small letter of the Latin name of the substance, *e.g.*, Carbon, C; Chlorine, Cl.

A formula is a collection of symbols which represents a molecule of any substance, *e.g.*, HCl.

An equation consists of symbols and formulæ with the algebraic signs of + and =. It is used to indicate the results of the action of substances on each other. There must always be the same number of atoms of each element on each side of the = sign.



Atomic weight is the weight of one atom of any element compared with the weight of an atom of hydrogen. H being one, O is sixteen, C twelve, N fourteen.

Molecular weight is the sum of the weights of all the atoms comprising the molecule of a substance, *e.g.*, H₂O = 18, or CO₂ = 44.

Valence and atomicity are terms used to express the combining power of



one atom of an element as compared with that of an atom of hydrogen. It is indicated by one or more dashes attached to the symbol, *e.g.*, Cl' is univalent; O'' is divalent; N''' is trivalent; C^{iv} is quadrivalent. Each of these elements unites respectively with one, two, three, and four of hydrogen.

INORGANIC AND ORGANIC SUBSTANCES.

11. This form of subdivision may generally be shown by the use of dry heat. Subjected to a temperature of 1,000° F., the great majority of inorganic bodies show little or no change in their color or condition; a few, like the compounds of arsenic, mercury, and ammonia, volatilize, but many of these recondense in their original state. Organic bodies, on the contrary, are, with few exceptions, decomposed by a heat under 1,000° F., and since they contain carbon in considerable quantity, they leave a charred mass or residue of charcoal, which by a continued application of heat may be burned away.

12. The demonstration of these facts, and the subdivision of the two great groups is shown by the following experiments:

Cleanse a slip of platinum foil by washing, and then ignite it in the Bunsen flame until it ceases to color the flame yellow.

First.—Place on the foil a piece of chalk, CaCO₃, the size of a large pin's head, and heat in the flame to a bright red. It neither blackens nor volatilizes, and thereby affords an example of a *non-volatile inorganic body*.

Second.—Cleanse the foil, and repeat the experiment, using a similar piece of ammonium chloride, NH₄Cl. It disappears or volatilizes without change of color. If the experiment is repeated in a dry test-tube, the NH₄Cl deposits on the wall of the tube. This is called a sublimate, and furnishes an example of a *volatile inorganic body*.

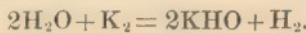
Third.—Cleanse the foil, and repeat the experiment, using a similar piece of starch, C₆H₁₀O₅. On being immersed in the flame, it catches fire and burns without the odor of burning hair; black residue of C remains, which may be entirely consumed. Here we have a *non-nitrogenized organic body*.

Fourth.—Cleanse the foil, and repeat the experiment, using a cutting from a finger-nail. Again the substance burns and blackens, but in addition it gives the odor of burning hair, since it is a *nitrogenized body*.

Fifth.—When organic bodies show cellular or other tissue-like structure under the microscope, they are said to be *organized*. This distinction is an important one, since a vast number of organic bodies have been artificially made in the laboratory, while no organized structure ever has, and probably never will be, artificially made.

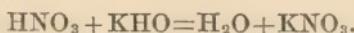
BASE. ACID. SALT.

13. A base or a metallic hydrate is formed by the substitution of a metal in place of one of the atoms in water.



The equation shows the action of potassium on water, potassium hydrate being produced and hydrogen set free. Bases which are soluble in water, as KHO and NaHO, are called *alkalies*. They turn red litmus blue.

An acid is a hydrogen compound which, in contact with a metallic hydrate, forms water, and the metal of the hydrate takes the place of the hydrogen in the acid.



Many acids are sour to the taste, and turn blue litmus red.

A salt is an acid in which the hydrogen has been replaced by one or more metals or compound radicals.

REACTION

14. Is a term used to indicate the action of bases, acids, and salts upon red and blue litmus. It may be either alkaline, acid, or neutral.

The most convenient form in which litmus can be employed is that of stained paper, to be prepared as follows:

In a test-tube place f 3 ij. of water, add half a dozen cubes of litmus, and boil the mixture for a couple of minutes. The result is a decoction of litmus (article 4, *third*). Decant and filter the solution (article 5) into a clean test-tube. Pour a portion of the filtrate into a clean watch-glass, pass through the fluid slips of filtering paper about one inch in width and a foot in length. As fast as the paper is soaked in the decoction, hang the slips up to dry. Fold the papers and preserve them between the leaves of a book. This is the blue litmus, and serves to detect an acid reaction by changing color to red.

Place in a clean dry watch-glass about gtt. v. of HCl. Warm the glass gently over the Bunsen flame, and when white fumes arise, take one of the slips of blue paper and pass it through the acid fumes about one inch above the watch-glass until it turns red. It is now in condition for the detection of an alkaline reaction, the blue color being restored by liquids possessing that condition.

If both blue and red litmus are unchanged by the fluid, the reaction is neutral.

DIVISIONS OF THE COURSE.

15. *Section First.*—Poisons, their manner of action, or tests and their chemical antidotes.

Section Second.—Water and its impurities.

Section Third.—Animal fluids.

Section Fourth.—Sediments and calculi.

Following this plan, we shall first take up the examination of poisons and their tests. The student will thus gain that experience in manipulation which is so necessary for the proper examination of urine and other complex fluids.

SECTION I.

POISONS.

16. The law does not define the term, but in common language a poison is said to be "anything capable of destroying life when taken in small quantity." For the purposes of the medical jurist this is not sufficiently exact.

Wormley defines a poison as "a substance which, when introduced into the body and being absorbed, or by its direct chemical action, or when applied externally and entering the circulation, is capable of producing deleterious effects."

Letheby says: "It is anything which otherwise than by the agency of heat or electricity is capable of destroying life, either by chemical action on the tissues of the living body, or by physiological action from absorption into the living system."

"To sustain a capital charge it is necessary to prove that the substance administered is a poison or other destructive thing, given with intent to commit murder." A poison must be a destructive thing, but a destructive thing is not necessarily a poison. A destructive thing may act mechanically, as in the case of needles and fine-chipped horsehair.

PHYSIOLOGICAL DIVISIONS.

17. According to their *physiological action* poisons are divided into corrosive, irritant, and neurotic. Examples of the first group are found among the strong mineral acids and caustic alkalies; of the second, among various metallic salts, and of the third, among such substances as morphia, strychnia, and other alkaloids.

It often happens that the action of a poison varies with the dose; strong H_2SO_4 is a corrosive; if dilute, an irritant. So oxalic acid may act either as an irritant or as a neurotic, according to the dose.

CHEMICAL DIVISIONS.

18. As in the case of other substances, poisons may be divided into inorganic and organic. The former of these includes the so-called metallic poisons, many acids, and the alkalies. The latter deals with certain vegetable substances, as opium, the active principles of which are called alkaloids. Certain highly noxious animal secretions may be added to this group, but we shall not have space for their consideration.

PURIFICATION.

19. In the tests given for the different poisons it is understood that the substance is comparatively pure ; but if it is necessary to search for it in articles of food or in vomited matter, it must be separated as completely as possible from insoluble matters by straining and filtering. If it is mixed with soluble albuminoid material, the process of dialysis must be resorted to. For a description of this the student is referred to any modern chemical text-book.

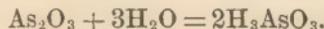
INORGANIC POISONS.

Arsenic. As''' and v = 75.

PREPARATIONS IN ORDINARY USE.

20. *First.*—Elementary, commonly called metallic arsenic, has a steel-gray lustre. Mixed with oxide it is black ; it is used as an insecticide for flies ; it unites with other metals, forming fusible, brittle, hard alloys. Is poisonous, probably by conversion into oxide.

Second.—Arsenious oxide, As_2O_3 ; white arsenic, ratsbane, arsenious anhydride, is white, odorless, and nearly tasteless ; is more frequently used than any other poison ; is also used by women as a cosmetic ; and in medicine. The vitreous kind more soluble than porcelainous. As_2O_3 is about 40 times more soluble when *boiled in water for one hour* than when treated with cold water for same time. 1,000 grains of cold water dissolve less than 2 grains arsenious oxide in 24 hours. Solution in water is arsenious acid, or hydrogen arsenite,



Where the insoluble compounds of arsenic act as poisons it is generally owing to the formation or presence of H_3AsO_3 . The arsenites are used in medicine, and in calico printing.

Third.—Arsenic oxide As_2O_5 , produced by strongly heating arsenic acid, H_3AsO_4 . Arsenic acid is formed by action of HNO_3 on As_2O_3 , is used in forming magenta dye. Arsenious iodide, AsI_3 , with mercuric iodide, HgI_2 , forms Donovan's solution.

Fourth.—Realgar, As S_2 , or red algar, and orpiment, As_2S_3 , or the golden pigment, are used as paints.

Fifth.—Liquor potassii arsenitis, or Fowler's solution, is formed by boiling As_2O_3 in water containing K_2CO_3 , and coloring with comp. tinct. lavender. It contains 4 grains arsenic to the ounce. Long boiling in strong solution is required to prepare it properly.

Sixth.—Paris-green, or Scheele's green, is an arsenite of copper $\text{Cu}^{\prime}\text{HAsO}_3$. Schweinfurth's green is a mixture of arsenite and acetate of copper. Both are used as pigments. Paris-green also used as a domestic insecticide.

GENERAL TESTS.

BY HEAT IN SUBLIMATION-TUBE.

21. *First.*—Draw sublimation-tubes 3 inches $\times \frac{1}{8}$ in diameter.

Second.—Sublimation test. Heat minute portion of As_2O_3 in tube. Verify diamond-like reflection of crystals of the sublimate in sunshine.

Third.—Heat small portion of metallic As in tube. Note that sublimate is in zones, that nearest heat is steel gray; above that black; above that dirty gray. From a very minute portion of As, a brown and even yellow sublimate may be obtained, as in certain forms of Marsh's test.

Fourth.—Oxidation test. Heat As sublimate in tube after breaking lower end, hold tube inclined at an angle of 45° in flame. Crystalline sublimate of As_2O_3 forms. To break tube, heat pointed end in flame, and then touch it to a drop of water, when it fissures and an opening is easily made.

Fifth.—Reduction test. Place minute quantity of As_2O_3 in tube, and above it a chip of dry charcoal. Apply the flame to charcoal region of tube first, and then to the As_2O_3 ; the latter as it passes hot charcoal is reduced, and black sublimate of As is obtained.

Sixth.—Oxidize this sublimate as in test *fourth*.

Seventh.—Reduce As_2S_3 by potassium ferrocyanide, mingling them together dry, place in sublimation-tube, heat; black arsenic ring forms.

Eighth.—Examine Paris-green by sublimation test.

HCl AND H_2S TEST.

22. Take f $\frac{1}{2}$ j. of water in a small flask; add two grains of As_2O_3 , and boil for five minutes; a portion dissolves; H_3AsO_3 arsenious acid forming. Keep this solution until arsenic examination is finished.

First.—In a large test-tube place water to a depth of one inch; add f $\frac{1}{2}$ j. of solution H_3AsO_3 . To this add gtt. xx. of HCl; no visible effect is produced.

Second.—Pass H_2S gas through the mixture, or fill the tube nearly full with strong H_2S solution; a yellow precipitate of As_2S_3 forms.

Third.—Warm the contents of the tube, and, closing its mouth, agitate it violently to promote the separation of the precipitate from the fluid.

Fourth.—Collect the precipitate upon a filter and wash with warm water.

Fifth.—With a glass rod place a small portion of the moist precipitate in each of three watch-glasses.

Sixth.—Examine contents of one watch-glass with NH_4HS ; it dissolves.

Seventh.—Examine contents of second glass with NH_4HO ; it dissolves.

Eighth.—Examine contents of third glass with strong HCl; it does not dissolve.

Ninth.—Mix a little of the dried precipitate As_2S_3 with two or three times its bulk of potassium cyanide; note the odor of the cyanide. Heat from above downward in a sublimation tube; arsenic is reduced, a black metallic mirror forming.

This examination of the precipitate from fourth to ninth is necessary to prove that it is an arsenic sulphide, since yellow precipitates with H_2S are given by other substances.

Tenth.—In a small test-tube place f 3 ss. of water, add gtt. xx. of solution H_3AsO_3 , fill the tube nearly full with H_2S solution; a yellow color is produced, but no precipitate. Add to the mixture gtt. xv. of HCl; a precipitate forms. This shows the necessity of always adding HCl to the solution when it is to be examined by the H_2S test.

23. NH_4HS gives yellow color with arsenious solution, but no precipitate until HCl is added in excess, when As_2S_3 is thrown down.

SPECIAL TESTS.

24. *Ammonio-sulphate-copper test.*—In a small tube place f 3 ij., or about $7\frac{1}{2}$ cubic centimetres of water; add gtt. three to five of dilute NH_4HO ; treat the mixture with solution CuSO_4 until the precipitate ceases to dissolve. To the ammonio-sulphate thus prepared and containing a slight excess of cupric hydrate, Cu^{+2}HO , add gtt. xx., or more, of solution H_3AsO_3 (22); a green precipitate, cupric arsenite, $\text{Cu}^{+}\text{HAsO}_3$, is thrown down. Shake the mixture and pour one-half into another tube; examine one portion with HNO_3 and the other with NH_4HO ; the precipitate dissolves in both cases, giving a colorless solution in the first, and a blue solution in the second instance.

25. *Ammonio-nitrate-silver test.*—To f 3 j. of water in a test-tube add a crystal of AgNO_3 , the size of a large pin's head; the test is then performed as in the preceding case, substituting this silver solution for that of cupric sulphate. The solution of AgNO_3 is added to the highly diluted NH_4HO until the white precipitate of silver oxide ceases to dissolve. To this ammonio-nitrate of silver gtt. xx., or more, of H_3AsO_3 solution is added; a canary-yellow precipitate of arsenite of silver, Ag_3AsO_3 , forms. Divide

the precipitate as in the ammonio-sulphate-copper test. Examine with NH_4HO and HNO_3 . It gives a colorless solution in each case. If any portion of precipitate fails to dissolve in HNO_3 , it shows the presence of some chloride as an impurity.

26. Reinsch's test.—Examine the purity of materials as follows: In a small test-tube f 3 ij. of water and gtt. xx. of HCl, introduce two or three slips of copper foil; heat to boiling, and keep at 212° F. for five minutes, replacing the water as it evaporates. If the copper remains perfectly bright, the materials are sufficiently pure for ordinary testing.

Add f 3 ss. of H_3AsO_3 (22) solution to 3 ij. of water in clean test-tube, introduce half dozen slips of Cu and gtt. xx. of HCl; boil as before. The arsenic deposits as a gray coating on the Cu; as it thickens it becomes black.

In this test other substances besides arsenic may deposit on the Cu. To prove that the coating is arsenical, rinse the Cu slips with water from washing bottle, dry gently by pressure between folds of bibulous paper, place in sublimation-tube, heat; arsenical coat gives a ring of As_2O_3 crystals on tube, and if the quantity is considerable and the tube very narrow, the black arsenic mirror may appear. Such As_2O_3 rings may be tested by the solution tests to demonstrate their nature.

This test may be applied directly to organic mixtures containing As_2O_3 ; as vomited matters, stomach contents, etc. In that case the materials should be digested with dilute HCl (1HCl to $6\text{H}_2\text{O}$) for an hour, or longer, on the water-bath. The solution obtained should then be boiled with Cu slips, and the deposit examined as before.

27. Marsh's test consists in the conversion of the arsenic into arsenite of hydrogen and its examination. For the description of this test the student is referred to larger works.

TOXICOLOGY.

28. As_2O_3 acts as a poison either by internal or external administration. The symptoms are usually those of an irritant; occasionally they are those of a neurotic. Where solutions have been taken they are sometimes almost immediate, generally they come on in from half an hour to an hour. Cases are related in which they have been deferred six, nine, ten, and sixteen hours.

The smallest fatal dose administered internally was two grains..

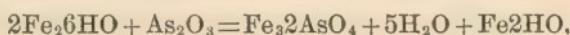
Shortest period in which death has occurred is two hours; generally in from twelve to thirty-six hours.

External application to ulcers, abrasions, eruptions, has caused death within thirty-six hours. One man poisoned two wives in succession by introducing As_2O_3 into the vagina. Use of aniline dye into which arsenic enters, and of wall-papers colored with Paris-green have caused slow arsenical poisoning.

ANTIDOTES.

29. The best are freshly prepared hydrated peroxide of iron, and dialysed iron. The hydrated peroxide or ferric hydrate may be prepared by adding the muriated tincture or perchloride of iron, Fe_2Cl_6 , to an excess of solution of ammonia, the ferric hydrate, $\text{Fe}_2\text{6HO}$, is thrown down as a red gelatinous precipitate. The mixture is to be well agitated and filtered through cloth; after the fluid has drained off, more water may be poured over the precipitate to remove the excess of NH_4HO . The moist magma may then be administered *ad lib.*

Ferric hydrate acts by converting the soluble As_2O_3 into an insoluble ferrous arseniate, according to the following equation :

**Antimony, Stibium. Sb''' and v = 122.**

PREPARATIONS IN ORDINARY USE.

30. Various alloys, as type metal, pewter, Britannia metal.

Sulphide, Sb_2S_3 , needle-like crystals, the powder used by women to pencil eyelids.

Kermes mineral, antimonii oxysulphuretum, is a mixture of oxide with tri- and penta-sulphide.

Tartar emetic, tartrate antimony and potassa, $\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$. Colorless or white crystals, rhombic octahedra, effloresce, odorless, nauseous metallic styptic taste. Soluble in fifteen of cold or two of hot H_2O . Insoluble in alcohol.

Antimonial wine is tartar emetic dissolved in sherry.

GENERAL TESTS.

BY HEAT IN SUBLIMATION-TUBE AND ON CHARCOAL.

31. Tartar emetic heated in sublimation-tube blackens and gives empyreumatic odor. In the blowpipe flame fuses and oxidizes rapidly, giving white coating on the coal.

HCl AND H_2S TEST.

32. Dissolve 10 grs. of tartar emetic in $\frac{1}{2}$ j. of water in a small flask, heating if necessary. Keep the solution till the tests are finished.

First.—In a large test-tube place $\frac{1}{2}$ ij. of the solution of $\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$, add a drop or so of HCl; a white precipitate forms which dissolves in excess of HCl, and is reprecipitated by H_2O . This is Sb_2O_3 .

Second.—Pass H_2S gas through the above mixture, or fill the

tube nearly full with strong H_2S solution, Sb_2S_3 is thrown down as an orange-red precipitate.

Third, fourth, fifth, sixth to be conducted as in the case of arsenic. The precipitate dissolves in NH_4HS (22.6).

Seventh.—The precipitate does not dissolve in NH_4HO (22.7).

Eighth.—It does dissolve in HCl (22.8).

The reactions of the antimony sulphide with NH_4HS , NH_4HO , and HCl serve to distinguish it from other reddish precipitates formed by H_2S in acid solutions. From arsenious sulphide it is distinguished by its different action with NH_4HO and HCl .

SPECIAL TESTS.

33. Ammonio-sulphate-copper, and ammonio-nitrate-silver do not act as in case of H_3AsO_3 (24 and 25).

34. *Reinsch's test*.—Conduct in the same manner as for arsenic, omitting the purity test, since the materials have already been examined in study of As. Use f. 3 j. of the solution of tartar emetic. The deposit on the Cu may be bluish-black, purple, or violet (26).

On heating the washed and dried Cu slips with their deposit in the sublimation tube, the sublimate is generally amorphous or non-crystalline, and closer to the Cu slips than in the case of As_2O_3 (26).

35. *Marsh's test*. In some respects tartar emetic shows similar reactions to those offered by H_3AsO_3 , but in others it is radically different, and is, therefore, easily distinguished therefrom. The student is referred to chemical text-books.

TOXICOLOGY.

36. In large dose the antimony poisons conform to the irritant group.

The smallest fatal doses of tartar emetic recorded are: in a child, three-fourths of a grain; in an adult, two grains. These are exceptional; ten grains is generally regarded a poisonous dose.

Time of death varies. Three-fourths of a grain administered to a child caused death in *one hour*. In a lady twenty-one years of age death occurred in seven hours.

Slow poisoning by tartar emetic formerly quite common. Small doses were given from time to time, and the condition of the gastric mucous membrane so perverted, that death finally ensued from apparently natural causes. By alternating small doses of tartar emetic with small doses arsenious oxide, the poisoner often succeeded in completely avoiding detection.

ANTIDOTES.

37. When there is no vomiting, use stomach-pump. Strong infusions and decoctions of vegetable astringents, as cinchona, oak-bark, green tea, are recommended as chemical antidotes. Their manner of action is not evident, and their usefulness is denied by some.

Mercury, or Quicksilver, Hydrargyrum. Hg' and " = 200.

PREPARATIONS IN ORDINARY USE.

38. The metal, silver-white fluid, boils 662° F., solidifies 39° F.

The alloys of Hg with other metals called amalgams, are used in making mirrors.

Hydrarg. cum creta., blue pill, mass hydrarg., and ungu. hydrarg. contain Hg very finely subdivided.

Two series of Hg compounds; the sub, or *ous* are mild, and the per, or *ic* are energetic poisons.

ous Series.

Mercurous oxide, Hg_2O , black.

Mercurous sulphide, Hg_2S , black.

Mercurous chloride, $HgCl$, calomel.

Mercurous iodide, HgI , green.

Mercur-ammonium chloride, NH_2HgCl , is white precipitate.

ic Series.

Mercuric oxide, HgO , yellow or red.

Mercuric sulphide, HgS , cinnabar and vermillion.

Mercuric chloride, $HgCl_2$, corrosive sublimate.

Mercuric iodide, HgI_2 , red.

GENERAL TESTS.

BY HEAT IN SUBLIMATION-TUBE.

39. *ous* Series, use calomel.

Sublimes without fusion, yellow hot, white cold (21).

ic Series, use corrosive sublimate.

Fuses, then sublimes, yellow hot, white cold.

HCl AND H_2S TEST.

40. Calomel $HgCl$ is not soluble in H_2O . $\frac{ij.}{ij.}$ may be suspended in $f\frac{z}{z} j.$ of H_2O by agitation. Shake the mixture each time it is used.

First.—Place $f\frac{z}{z} ij.$ of the mixture in a large test-tube, add gtt. v. of HCl, no action.

Second.— H_2S in above mixture gives black precipitate, Hg_2S , which forms immediately.

Third.—Collected on a filter, washed, and treated with strong HNO_3 , in a watch-glass, these black sulphides of mercury are not dissolved. They dissolve in a mixture of HCl and HNO_3 , or aqua regia.

Prepare solution, 10 grs. $HgCl_2$ to $f\frac{z}{z} j.$ of H_2O .

First.—Place $f\frac{z}{z} ij.$ of the solution in large test-tube, add gtt. v. of HCl, no action.

Second.— H_2S gives a light colored, then brown, then black precipitate of HgS , which turns red when dried and strongly heated.

SPECIAL TESTS

41. Act differently, according as it is an *ous* or *ic* salt.

ous Series.

For each test, use f 3 j. of the mixture.

Aq. calcis, gives black wash, Hg_2O .

KHO , gives black oxide, Hg_2O .

NH_4HO , gives black oxide Hg_2O .

ic Series.

For each test, use f 3 ss. of the solution.

Aq. calcis, gives yellow wash, HgO .

KHO , gives red oxide, HgO .

NH_4HO , gives white mercur. amm. chloride.

42. For corrosive sublimate, bichloride, or perchloride of mercury, the following additional tests may be used, employing f 3 ss. of the HgCl_2 solution for each.

KI solution gives a yellow to red precipitate ; add it very carefully. The precipitate is soluble either in HgCl_2 solution or in KI solution. Prepare the KI solution by dissolving a crystal of KI , the size of a pepper corn, in f 3 j. of water.

Albumen, gives a white, tolerably insoluble compound.

43. *Reinsch's test* is to be performed in the same way as for H_3AsO_3 .

The coating on the Cu may be silver-like or gray. On heating the washed and dried slips in sublimation-tube a gray sublimate of minute mercurial globules may be obtained ; rubbed with a wire or splinter of wood these coalesce and form a large globule of Hg .

44. *Galvanic test*.—Place a drop of HgCl_2 solution on a gold surface ; touch the gold through the drop with a steel knife-blade. Hg deposits on gold as a silver-like stain ; it may be polished. This test is useful to detect presence of bichloride in calomel.

TOXICOLOGY.

45. The majority of cases arise from the use of corrosive sublimate, which acts as an active irritant poison when administered in sufficient quantity, either internally or externally. Inhalations of Hg vapors and the application of mercurial preparations to the skin produce slow or chronic poisoning. Vermilion HgS is stated by some to be poisonous, but this is denied by others.

Smallest fatal dose recorded for an adult was six grains of corrosive sublimate. A woman recovered after taking one ounce.

Shortest fatal period was half an hour in the case of a man. Death has occurred on the sixteenth day.

ANTIDOTES.

46. In acute poisoning the immediate administration of albumen, best obtained from white of egg, is the safest antidote. A precipitate is produced which will dissolve slowly in gastric juice, therefore the stomach-pump

should be used to remove it, and more albumen administered. In chronic poisoning KI is used.

Lead, Plumbum. Pb " and iv = 207.

PREPARATIONS IN ORDINARY USE.

47. The metal was dedicated to Saturn by the ancients, hence "Saturnine poisoning;" it is used for lining water-cisterns and for water-pipes. Pb dissolves in H₂O containing H₂CO₂, a carbonate being formed. Lead enters into the composition of many alloys, as pewter, Britannia metal, solder; in shot it is alloyed with As.

Litharge, or massicot, PbO, used as a paint, boiled with olive-oil forms the oleate of lead, or emplastrum plumbi. Minium Pb₃O₄, or red lead is the ordinary red paint.

Carbonate of lead, PbCO₃, is the ordinary white lead paint, used also as the vehicle for other colored paints; it is employed by gas-fitters to make gas-tight joints. Dissolves completely in HNO₃; thus mixture with barium sulphate may be detected, the latter not dissolving in HNO₃.

Chrome yellow, PbCrO₄, chromate of lead, is the ordinary yellow paint. By boiling this with lime and water, orange chrome is produced.

Sugar of lead, or acetate, Pb₂C₂H₃O₂, is crystalline, with sweet, astringent taste, used in medicine externally and internally; also in certain sugar refining operations.

Goulard's extract, or subacetate of lead, also used in medicine.

GENERAL TESTS

HEAT IN SUBLIMATION-TUBE AND ON CHARCOAL.

48. Pb₂C₂H₃O₂ heated in test-tube blackens and gives off odor; other compounds than the acetates mentioned do not give odor; some of them change color.

Heated on charcoal in the blow-pipe flame, lead compounds give a bead of metallic lead, surrounded by a yellow ring of litharge, PbO.

HCl AND H₂S TEST.

49. Dissolve ten grains of the acetate, or of the nitrate of lead, in f $\frac{1}{2}$ j. of H₂O, and keep the solution till tests are finished.

First.—Place f $\frac{1}{2}$ ij. of the lead solution in a large test-tube, add a drop or so of HCl, a white precipitate of PbCl₂ separates, which is soluble in 33 parts of H₂O.

Second.—Pass H₂S gas through the acidulated mixture, or fill the tube nearly full with strong H₂S solution, a dark brown precipitate of PbS is thrown down.

Third.—Collected on a filter, washed (22, *Third* and *Fourth*), and treated in watch-glass with strong HNO₃, and heat, the black sulphide, PbS, is converted into a white sulphate, PbSO₄.

SPECIAL TESTS

50. Use $\frac{1}{2}$ j. of the lead solution for each test.

First.—Prepare a KI solution, as in testing for mercury (42); it gives a satin yellow PbI_2 , slightly soluble in H_2O . Boil with H_2O , filter hot; on cooling, beautiful golden scale-like crystals deposit.

Second.— H_2SO_4 gives white $PbSO_4$. In very dilute solution, as a lemonade, H_2SO_4 is a preventive against chronic lead-poisoning in workmen. Soluble sulphates also precipitate the Pb as $PbSO_4$.

Third.—Prepare K_2CrO_4 solution as in case of KI (42); it gives chrome-yellow $PbCrO_4$.

TOXICOLOGY.

51. Acute poisoning is rare, and nearly always by the acetate; when it happens, the lead compound acts as an irritant.

Dose one to three grains, every two or three hours, has produced poisoning symptoms. A drachm dose was nearly fatal; an ounce dose has been taken without serious result.

Chronic poisoning is common in painters, plumbers, and other workers in lead, and with its compounds. Common red rubber plates for artificial teeth have produced evil results. Slow lead-poisoning also occurs by the metal dissolving in H_2O from the tanks and pipes in which it is kept or conveyed. A much greater portion of the metal is dissolved by rain than by spring waters which contain sulphates (50, *Second*).

To examine water for lead, evaporate a large quantity to one-fiftieth of its volume in a small porcelain capsule, dropping small portions into the capsule from time to time. Treat with strong HNO_3 ; evaporate to dryness; dissolve residue in water; filter; treat portions of filtrate with H_2S and other tests. Be sure that the lead found does not come from the glaze on the capsule.

ANTIDOTES.

52. For acute poisoning, stomach-pump, and solution sulphate of magnesia, or of sulphate of soda.

As a prophylactic in lead-works, sulphuric acid lemonade.

In chronic poisoning, in which it acts as a cumulative poison, lead may be eliminated from the system by the internal administration of iodide of potassium. Lead may be found in the urine after the treatment is well under way.

Copper, Cuprum. Cu' and " = 63.5.

PREPARATIONS IN ORDINARY USE.

53. The metal was dedicated to Venus by the ancients. Together with its alloy, brass, it is used in making culinary vessels. Small traces of Cu are found in the human body.

Cupric oxide, CuO , is black. Cuprous oxide, Cu_2O , is red; both are of importance in testing for diabetic sugar, and in organic analysis.

Pyrites, CuS, is a common brass-like ore. When freshly precipitated CuS is black.

CuCO₃ is the greenish crust which forms on copper vessels when exposed to damp air. The green paint *Verditer* contains this substance.

Blue vitriol, cupric sulphate, CuSO₄·5H₂O, is in common use for many purposes.

Cupric arsenite, or Paris-green (20, *Sixth*), is in common use as an insecticide ; is often used by suicides.

Cupric acetate, Cu₂C₂H₃O₂, is green. Verdigris is a subacetate. Brunswick-green and Schweinfurth-green are mixtures of arsenite, acetate, and carbonate of copper.

GENERAL TESTS.

HEAT IN SUBLIMATION-TUBE AND ON CHARCOAL.

54. *First.*—Blue vitriol heated in the tube turns white and gives off its H₂O. Paris-green gives crystalline sublimate of As₂O₃.

Second.—Cu compounds, if powdered, moistened in a watch-glass with HCl, and introduced on fine glass rod, or on iron-wire into a Bunsen or a spirit-flame, give to it green and blue tints.

Third.—Some compounds mixed with Na₂CO₃ give a bead of red metallic copper when heated on charcoal in blow-pipe flame.

HCl AND H₂S TESTS.

55. Use the saturated solution of CuSO₄·5H₂O.

First.—Place f 3 ij. of water in a large test-tube, add gtt. x. of copper solution, to this gtt. v. of HCl ; no reaction except slight change in tint.

Second.—Pass H₂S through the acid mixture, or add H₂S solution ; a brownish-black precipitate falls.

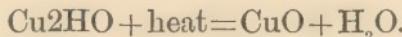
Third.—Collected on filter, washed and treated while moist in a watch-glass with strong HNO₃, and heat, the black sulphide CuS dissolves, the blue CuSO₄·5H₂O being formed.

SPECIAL TESTS.

56. In a small test-tube f 3 j. of H₂O, and gtt. x. of Cu solution, mix, add NH₄HO by drops very slowly, the pale blue cupric hydrate Cu₂HO is thrown down ; it dissolves readily in excess of NH₄HO, forming a blue or purple solution ; is known as ammonio-sulphate of copper.

57. In a small test-tube f 3 j. of H₂O, and gtt. v. of Cu solution, to this add gtt. xx. of KHO, sp. gr. 1,050. The pale blue cupric hydrate is thrown down ; it does *not* dissolve in excess of KHO. On boiling the mixture, if the KHO is in sufficient excess, the

blue hydrate is converted into the black oxide, as shown in following equation :



To prove the necessity of excess of KHO, repeat the operation, using only two or three drops of KHO instead of twenty. On boiling, the precipitate remains blue.

Since KHO solution absorbs CO₂ from the air, it is converted into a carbonate, and fails to act. When this happens, more than gtt. xx. must be used, and if necessary, a fresh solution of KHO prepared.

Care in proving that enough KHO is always added to produce the black CuO on boiling, makes this test perfectly reliable in the deoxidation test which follows.

58. Deoxidation test.—Take an eighth of an inch cube of grape-sugar, dissolve in f 3 ij. of H₂O in a test-tube. Note how slowly it dissolves. Keep the solution.

First.—Prepare a dilute solution of the above, gtt. x. to f 3 j. of water. Add gtt. v. of Cu solution, then add KHO, potassic hydrate very slowly. The first drop or so gives the pale blue Cu₂HO, which dissolves as the remainder of the gtt. xx. is added, giving a purplish solution. On boiling this a yellow to red precipitate of sub-oxide of copper Cu₂O is produced, instead of the black CuO.

Second.—Repeat the experiment, using only gtt. iii. to v. of KHO. The cuprous oxide Cu₂O is not formed, thereby showing the necessity for the use of *an excess of KHO*.

Third.—Prepare a very dilute solution of sugar, one drop to f 3 iv. of water, and use f 3 j. of this ; test it with gtt. v. of cupric sulphate and gtt. xx. of potassic hydrate. On boiling, though a little of the red Cu₂O may be precipitated, it is not seen, since it is masked by the large amount of black CuO present.

Fourth.—Repeat the experiment, using only a single drop of the cupric sulphate solution. A very faint reddish precipitate will appear if the reagents are properly adjusted in quantity. From this it is seen, that before it is decided that sugar is not present in a sample of urine it must be tested with a very small quantity of copper solution to find small traces.

Fifth.—Prepare a solution of cane-sugar similar to that of grape-sugar, and test it in the same manner. It does not throw down the red Cu₂O, since it does not possess the deoxidation or reduction power of grape-sugar.

59. Fehling's solution affords a convenient method of applying the copper-test for the quantitative determination of sugar. It is prepared as follows : Dissolve 34.64 grammes of pure crystal-

lized cupric sulphate in 200 cubic centimetres of distilled water ; dissolve 80 grammes of sodium hydrate in 600 c.c. of water, and add 173 grammes of Rochelle salt (sodium and potassium tartrate). Mix the two solutions, agitate thoroughly, and make up to one litre. Preserve in well-stoppered bottles, or in sealed tubes. One c.c. is exactly precipitated by 5 milligrammes of glucose, or grape-sugar.

Pour 5 c.c. into a test-tube, heat to boiling, add the suspected sugar solution gradually by drops. If glucose is present, the blue tint changes to green, and the yellow or red cuprous oxide is precipitated. When the blue color is entirely discharged, the whole of the copper is precipitated.

60. Ferrocyanide test. To f 3 j. of water add a crystal of prussiate or ferrocyanide of potassium the size of a pin's head. To this solution add a drop or so of the copper solution. A chocolate-brown precipitate of ferrocyanide of potassium forms.

Albumen solution gives a precipitate with solution of cupric sulphate.

Iron or steel—a knife-blade or a needle—dipped into a solution containing Cu, shows a red coating of metallic copper on its surface in a short time.

TOXICOLOGY.

61. Copper compounds belong to the irritant poisons ; their criminal use is rare.

Half an ounce of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ killed a woman in sixty hours ; 3 ij. was nearly fatal ; 3 j. has failed to be fatal. Poison cases by Cu generally arise from its introduction into articles of food from copper or brass vessels in which it has been cooked. Especially is this the case if acids, oils, or fats have been used in the cooking. All pickles, preserves, vegetables, as string-beans and candied fruits of a bright green tint, are to be regarded with suspicion, since the color is generally produced by the presence of copper. In the case of pickles, this may often be shown by piercing them with a needle and leaving it *in situ* for some time ; on being withdrawn it shows a copper coating.

In making bread from damaged flour, cupric sulphate is often introduced into the dough to improve the whiteness of the bread.

The use of copper in quantity as an inferior gold alloy for teeth-plates has produced evil results.

The shortest fatal period recorded is four hours, in a child of sixteen months old, from cupric sulphate. Sour-kraut from a copper vessel killed a young woman in twelve and her mother in thirteen hours. Three and nine days are also recorded.

ANTIDOTES.

62. Albumen and demulcents followed by stomach-pump. Iron filings and iron by hydrogen are also recommended. In the latter case the copper is reduced to the metallic state.

63. EXAMINATION FOR METALLIC POISONS—SUBSTANCE UNKNOWN.

SUBSTANCES.	SOLID.		TESTS FOR SOLUTIONS.		Other Tests.
	Irat in Tube.	HCl.	H ₂ S.		
1. Arsenic, arsenious * Sublimes crystals	.....	Yellow, sol. in Reinsch—(Cu + HCl) gray to black deposit on Cu. Sublimes in heated tube, As ₂ O ₃ crystals at distance from Cu. Antidotes, hydrated perox. iron, dialyzed iron.			
2. Antimony, tartar Blackens. emetic.	White, sol. in Orange, sol. in HCl; insol. in NH ₄ HO.	in Reinsch—(Cu + HCl) violet deposit on Cu. Sublimes in tube. Amorphous, close to Cu. Antidotes, decoction of oak-bark, tea or other astringents, stomach-pump.			
3. Mercury, chlorides. Sublime.	.....	Black, insol. in HNO ₃ .	in Reinsch—(Cu + HCl) gray or silver deposit on Cu. Sublimes in tube as minute drops, which unite if rubbed. Galvanic test; lime-water test; KI test. Antidote, albumen and stomach-pump.		
4. Lead, acetate Blackens.	White if strong.	Black, whitened by HNO ₃ .	(NH ₄ HO) white, insol. in excess. KI yellow precipitate, satin-like reflection. Antidote, acute — magnesium sulphate; chronic—pot. iod. (KI).		
5. Silver, nitrate Fuses.	White, curdy, soluble in HNO ₃ .	Black, sol. in HNO ₃ .	in (NH ₄ HO) pale white, sol. in excess. KI pale yellow. Phos. soda, pale yellow, sol. in HNO ₃ and NH ₄ HO. Antidote, † solution of salt, NaCl.		
6. Copper sulphate Whitens.	.....	Black, sol. in HNO ₃ .	in (NH ₄ HO) pale blue precipitate; purple solution with excess. Pot. ferrocyanide, chocolate. Metallic Cu precipitated by Fe. Antidotes, albumen and stomach-pump, iron filings, iron by hydrogen.		

* Heated with carb. soda in tube, black sublimate.

† In using AgNO₃ as a local application, it is well to neutralize any excess by applying weak solution of NaCl to the part.

Phosphorus. P''' and v = 31.

PREPARATIONS IN ORDINARY USE.

64. The element presents two allotropic forms: 1st, Waxy and clear yellow; 2d, red. The first shines in the dark, and fumes in the air with a garlic-like odor. It is so combustible that it must be kept under water. The second does not shine nor fume; it also is very combustible. Phosphorus is largely used in the manufacture of matches, and in the preparation of a paste for poisoning rats; such paste contains about five per cent. of phosphorus. It also enters into the composition of various medicinal preparations, which are prescribed as aphrodisiacs, and in nervous debility.

TESTS.

65. *First.*—The peculiar garlic-like odor may be detected in very dilute solutions and mixtures of the free element.

Second.—Starch-iodide-potassium test. For this paper must be imbued with these substances. To prepare the starch solution, take a portion of starch the size of a large pin's head, place it in a watch-glass and crush it with $\frac{1}{3}$ ss. of cold water, transfer to a test-tube and boil. Add to this twice as much of KI as of starch, and dissolve; smear the central portion of a couple of two-inch filters with the preparation and dry.

In a watch-glass place a small portion of phosphorus and a drop or so of water; moisten a piece of the starch-iodide paper, and cover the mouth of the glass therewith. Ozone is developed, and the paper is turned blue, or if dry, brown.

A drop of AgNO_3 placed on paper, and exposed in the same manner is blackened.

Third.—Hydrogen test. Place $\frac{1}{3}$ j. of the mixture containing phosphorus in a test-tube, introduce some slips of zinc, and add gtt. xx. of H_2SO_4 ; traces of phosphuretted hydrogen, Ph_3 , are evolved, which may be detected by their luminosity in the dark, and by their blackening paper moistened with solution AgNO_3 .

TOXICOLOGY.

66. The element acts both as an acute and as a slow poison. In the first case it is a corrosive irritant; in the second it attacks the bones. The waxy variety is by far the more dangerous. In the acute form symptoms sometimes set in rapidly, generally within one or two hours; have been postponed for five days.

Smallest recorded fatal quantity one-fiftieth grain, by a child sucking two matches; one-eighth of a grain in case of a woman; large doses have been taken without fatal results.

Time of death, 30 minutes; 13 and 20 hours; 2 to 12 days; usually 3 to 7 days.

Two explanations of its action: 1st, as a direct blood poison; 2d, by conversion into phosphorus acid.

ANTIDOTES.

67. No true chemical antidote ; magnesia and chalk have been given with good effect. Emetics and stomach-pump if there is no vomiting. *Never give oil's or fats, as it dissolves therein, and its action is increased.*

ACIDS

68. May be divided into three groups : 1st, mineral acids, as sulphuric, hydrochloric, and nitric, which act as corrosive poisons when taken in the concentrated state, but if sufficiently diluted, may be swallowed in large quantities without injury ; 2d, citric, tartaric, and similar acids, which may be taken in a concentrated form, and only do injury when used in very large quantity ; 3d, oxalic and hydrocyanic acids, which are poisonous under all circumstances.

MINERAL ACIDS

69. Are extensively used in manufactures and as medicines ; they are intensely sour to the taste, and redden blue litmus. H_2SO_4 is oily and thick, while HCl and HNO_3 are limpid, like water. If strong they destroy clothing, if dilute they stain it ; H_2SO_4 and HCl giving a red stain, removable by NH_4HO ; the color of the stain varies somewhat with the dye in the cloth ; HNO_3 gives a yellow stain not removed by NH_4HO . By these reactions the nature of the acid thrown on clothing may be detected.

Sulphuric acid generally contains arsenic, derived from the pyrites used in its manufacture. As it is employed as an adulterant in vinegar, arsenic may thus be introduced into the body. HCl and HNO_3 , being prepared by the agency of H_2SO_4 , may also contain arsenic.

Aromatic sulphuric acid contains about twelve per cent. of strong H_2SO_4 . The acidum nitromuriaticum of the pharmacopœia, or aqua regia, is a mixture of HCl and HNO_3 .

TESTS.

70. *First.*—Prepare a solution of barium chloride, BaCl_2 , by dissolving a small quantity in f 3 ij. of water in a test-tube.

Second.—Prepare a solution of AgNO_3 in the same manner. Keep the solutions till the acid tests are finished.

Third.—Prepare dilute solutions of each of the three acids, gtt. v. to f 3 ij. of water.

Fourth.—Test each of these solutions with a few drops of BaCl_2 solution. HNO_3 and HCl , no precipitate ; H_2SO_4 , an exceedingly finely divided, white precipitate, which is insoluble in HNO_3 .

Fifth.—Prepare dilute solutions of HNO_3 and HCl in the same manner ; test them with the AgNO_3 solution. HNO_3 , no precipitate ; HCl , a white, curly precipitate of AgCl . Shake the contents

of the tube to promote the settling of the precipitate, decant the fluid, transfer the precipitate to two watch-glasses (22.5), examine one portion with HNO_3 , and the other with NH_4HO ; it is insoluble in the first and soluble in the second.

Sixth.—To detect the presence of HNO_3 place a few drops in a test-tube, introduce a slip of copper, when there is effervescence attended by escape of dense orange-colored fumes. If the acid is very dilute, concentrate it to a small quantity by evaporation in a watch-glass, and then apply the test.

TOXICOLOGY.

71. As already stated, the mineral acids are corrosives. If dilute and taken in very large quantity they may act as irritants.

As small a quantity as one fluid drachm of either of the strong mineral acids has caused death, but persons have recovered from much larger doses.

Death has not infrequently occurred from pouring strong acids down the throats of persons while they were asleep. It usually supervenes in from two to five hours, though it has been almost instantaneous. On the other hand, it may occur months afterward from stricture of the œsophagus.

The blue liquid known as sulphate of indigo contains H_2SO_4 , and has caused death.

The soluble salts with poisonous metals are poisonous, those with potassium, sodium, magnesium, calcium, are innocuous unless taken in very large doses, when they act as irritants.

By reason of their volatility, HNO_3 and HCl vapors have caused death. The result may be sudden by spasm of the glottis, or in a short time by inflammation of the mucous membrane of the air-passages.

It must be remembered that HCl is a normal ingredient of gastric juice, and this fact must be taken into consideration in forming an opinion regarding poisoning with that substance.

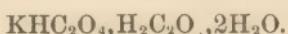
ANTIDOTES.

72. Magnesia suspended in water combines with the acid and neutralizes it. White of egg. Solution of soap is the most readily obtained. Solution of the alkaline carbonates may be used externally, but are not suitable for internal use, the escape of CO_2 distending the stomach.

Oxalic Acid. $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O} = 126$.

73. Generally regarded as the strongest of the organic acids, but may be studied here. Used in leather, straw, and other manufactures; in domestic economy to clean brass and remove ink-stains. Is in the form of colorless, transparent, odorless, four-sided, prismatic, soluble, non-deliquescent crystals, very like Epsom salt. It is sour to the taste, and reddens litmus, while Epsom salt is bitter. It stains black cloth a deep brown.

Oxalates occur in rhubarb plant, dock, sorrel, and certain lichens, and at times in the urine. Salt of sorrel is oxalic acid combined with acid oxalate of potassium.



TESTS.

74. *First.*—Acid taste, and reddens litmus in solution.

Second.—Crystals heated in a tube volatilize at 177° C., and if pure do not char like other vegetable acids; thus easily distinguishable from Epsom salt, which is non-volatile.

Third.—Solid heated in tube with strong H₂SO₄ is decomposed without charring into CO and CO₂ gases. Other organic acids char speedily.

Fourth.—Prepare a solution of oxalic acid in water. To a small portion add a few drops of solution of BaCl₂ (70), a finely divided, white precipitate is thrown down, if the solution is not too dilute. With soluble oxalates the precipitation is more complete. The precipitate dissolves without effervescence in HCl or HNO₃, but resists acetic acid, in which other precipitates with BaCl₂ dissolve, except the sulphate.

Fifth.—To another portion of the solution add solution of AgNO₃ (70, *Second*), a white precipitate is produced, soluble in hot HNO₃ and in NH₄HO, but insoluble in acetic acid. Other precipitates with AgNO₃ dissolve in acetic acid, except the chloride and cyanide, which are thus distinguished from the oxalate.

Sixth.—Solution of sulphate of lime also produces with oxalic acid and oxalates a white precipitate nearly insoluble in acetic acid, but very soluble in HCl or HNO₃.

TOXICOLOGY.

75. Death from the acid and from the salt of sorrel. Acid acts variously, according to dose and dilution; may exert a corrosive, an irritant, or a neurotic action. The symptoms may be immediate or in an hour or so.

The smallest recorded dose, one drachm, in youth of sixteen; half an ounce generally fatal, though recovery has followed much larger dose.

Time of death has been immediate; three, ten, twenty, and twenty-five minutes are recorded. Has been deferred for days.

ANTIDOTES.

76. Never use stomach-pump.

Never use alkaline carbonates, as oxalates of potash and soda are more poisonous than the acid.

Use as little water as possible.

Chalk or magnesia suspended in a little milk or mucilaginous drink is the proper thing. Scrapings from white-washed ceilings are excellent, if chalk is not available.

Emetics should be given after a time if there is no vomiting.

Hydrocyanic Acid. HCN or HCy = 27.

77. Also known as prussic acid. Anhydrous is volatile liquid with odor of bitter almonds. Is a constituent of bitter almonds and laurel water. May also be prepared from cherry, peach, and pits of other stone fruits.

Many of the cyanides are poisonous, HCy being set free by the action of the gastric juice.

The acidum dilution of the U. S. P. contains two per cent. of the anhydrous acid.

The aqueous solution decomposes quickly, especially in the light.

The toys known as "Pharaoh's Serpents" contain sulphocyanide of mercury.

TESTS.

78. *First.*—The peculiar odor of peach-bloom or bitter almond generally leads to its detection.

Second.—Place a small portion of KCy in a watch-glass, moisten with a little dilute H_2SO_4 ; in another watch-glass place a minute drop of solution $AgNO_3$, and holding it mouth downward cover the first watch-glass; the silver solution must not flow into the lower glass. After a short time the silver solution becomes turbid, $AgCy$ being formed; this is soluble in hot HNO_3 , and is thus distinguished from $AgCl$, with which it might be confounded (74, *Fifth*).

Third.—Liebig's test is performed in the same manner, substituting a drop of NH_4HS for the $AgNO_3$. In half an hour or less, the yellow NH_4HS is bleached, ammonium-sulphocyanate being produced; touching this with a drop of ferric chloride, Fe_2Cl_6 , a blood-red color is produced.

TOXICOLOGY.

79. One of the most powerful and rapidly fatal of poisons; many of its compounds almost equal it. Is a neurotic poison.

The smallest recorded fatal dose was equal to nine-tenths of a grain of anhydrous acid taken on an empty stomach. One grain may, but not necessarily must, be fatal; therefore, always resort to treatment.

The time of death with the anhydrous is almost instantaneous, "lightning-like." According to the quantity and dilution it varies, but is generally within a few minutes. If life is prolonged one hour, recovery is almost assured.

Even in the state of vapor, HCy will cause death instantly in birds.

ANTIDOTES.

80. Cold affusion; artificial respiration; ammonia; chlorine; stomach-pump.

Chemical antidotes little use, as there is no time. A mixture of proto- and per-sulphate of iron with a little caustic alkali is recommended.

ALKALIES.

81. The substances forming this group are potassa, KHO ; soda, NaHO ; and ammonia, NH₃HO. As their formulae indicate, the first two are hydrates of the metals potassium and sodium, while the third is the hydrate of the compound radical ammonium. They are greasy to the touch, and turn red litmus blue. Since their carbonates act in a similar manner they are also frequently included in the term alkali.

The alkalies and their carbonates are used in a great variety of manufactures, and also as medicines.

TESTS.

82. Heat. KHO, NaHO, and their carbonates only volatilize slowly at a red heat, hence they are called fixed alkalies (104 and 105).

NH₃HO and all its ordinary compounds are either volatilized or decomposed below a red heat, hence this body is called volatile alkali. This fact and the pungent odor of the gas, with its power to turn moistened red litmus blue, distinguish it from all other bodies (11 and 99, *Sixth*).

NH₃Cl and many compounds of NH₃ are odorless. In these cases the NH₃ gas may be set free by heating the body with a little potassium hydrate in a test-tube. Nitrogenized organic bodies (12, *Fourth*) also evolve NH₃ gas when treated with KHO and heat.

83. *Alkalimetry and volumetric analysis.*—If it is required to determine the quantity of alkali present, it may be done by the process in question, which is to be conducted as follows :

First.—Place a porcelain capsule on the water-bath in action. Introduce into the capsule a measured quantity, say ten cubic centimetres, of the alkaline fluid to be examined, or a weighed quantity of the solid dissolved in sufficient water, together with a small slip of blue litmus paper.

Second.—Fill a burette to the zero of the scale with dilute H₂SO₄, of such strength that one cubic centimetre shall be equivalent to ten milligrammes of the alkali. Add the acid by drops to the contents of the capsule, stirring continually with a glass rod until the slip of litmus turns red. The litmus should then be drawn up on the dry surface of the capsule, and allowed to rest for a minute or so; if it regains its blue color it must be returned, more acid added, and the operation repeated until the reddening is permanent. If the litmus loses its color introduce

a fresh slip. Toward the latter part of the operation the acid must be added very slowly and cautiously, or too much will be used, and the analysis lost.

Third.—It remains to read off from the scale the amount of acid used ; when multiplying the number of centimetres employed by ten, the number of milligrammes of alkali in the quantity examined is known.

We have purposely described the volumetric method in its simplest form for the sake of giving the student practice in manipulation. For the preparation of the usual normal and decinormal solutions, and of half-gramme molecule solutions, resort must be had to Fownes' and other text-books.

In a great number of cases, and especially in urinary analysis, the volumetric method may be used to advantage and with great saving of time.

TOXICOLOGY.

84. In the concentrated state the alkalies are powerful corrosives. Even when quite dilute they have a nauseous soapy taste, due to the rapid disorganization of the mucous surfaces.

The smallest recorded fatal dose of KHO is forty grains. NaHO is somewhat less energetic in its action ; half an ounce of either may be regarded as a fatal dose. NH₄HO is even more energetic in its action than the fixed alkalies. f 3 ij. are given as the fatal quantity. The symptoms are more distressing, the respiratory apparatus being also affected.

As in the case of the mineral acids, death may be very rapid, or after a few hours, or at a remote period from stricture of the œsophagus.

ANTIDOTES.

85. Never use the stomach-pump.

Give dilute vinegar or lemon-juice in quantity at once. These should be followed by olive-oil or milk. Opium for the pain, and stimulants if there is collapse after the poison is neutralized.

ORGANIC POISONS.

ALKALOIDS.

86. The term alkaloid is applied to certain essential principles which are extracted from various plants, and which resemble alkalies in that they unite with acids to produce salts. The members of the group of greatest interest are morphia and strychnia, with their salts. They are frequently used in medicine.

Morphia.

87. The alkaloid with its salts, together with the various preparations of opium, as laudanum, paregoric, extract opii, Battley's solution, McMunn's elixir, Dover's powder, etc.

TESTS.

88. In examining for the alkaloids, since the quantity available is always very small, the operations should be conducted with drops of concentrated solutions, or small crystals placed in watch-glasses, or on microscope slides.

Morphia and its salts, with concentrated HNO_3 , produce a yellow to an orange-red color.

Ferric chloride produces a blue color with neutral solutions of morphia or its salts.

TOXICOLOGY.

89. Some of the alkaloids are the most virulent of poisons. Their action may be either irritant or neurotic. Of these, morphia and strychnia both belong to the neurotic division. External as well as internal administration has been followed by fatal results.

Morphia in its action on the nervous system is a powerful narcotic.

The smallest recorded fatal dose is one-twelfth of a grain in an infant. One grain in divided doses during six hours caused death in a girl of nineteen. On the other hand, a druggist took seventy-five grains of sulphate of morphia and recovered.

The fatal period varies. The symptoms generally come on in a few minutes; sometimes four hours have elapsed before they appeared. A gentle-

man, aged fifty, took ten grains of sulphate of morphia, and died in two hours. An aged woman died in forty-five minutes. Death generally occurs in from ten to twenty hours, but may happen suddenly after several days have elapsed.

ANTIDOTES.

90. Use the stomach-pump as soon as possible. Wash out the stomach with infusion of coffee or of green tea in which charcoal powder is suspended. Encourage vomiting by tickling throat; emetics.

Strychnia.

91. The alkaloid, its salts, and the preparations of nux vomica. Employed in medicine and in various vermin-killers. It possesses a remarkable power of resisting decomposition by cold concentrated mineral acids and alkalis. Fermentation and putrefaction also have little effect upon it. Of the salts the acetate is the most soluble.

TESTS.

92. *Strychnia* and its salts possess an intense, peculiar bitter taste.

Place a small crystal on a slip of glass (microscope slide), and the glass on white paper; with a fine glass rod cover it with strong H_2SO_4 ; it dissolves without change of color. Alongside place a small crystal of potassium bichromate, and with another glass rod cover it with strong H_2SO_4 . After the acid has acted for a minute or so, draw the solutions together with one of the rods, when a blue color is produced which quickly turns to violet, then to red, and finally fades away.

Marshall Hall's test. Injected as a solution under the skin of a frog's back, even in very minute quantity, strychnia and its salts quickly produce violent tetanus. This condition may also be brought on in these creatures by the action of warm water, a fact which must be taken into consideration when employing them as a physiological test for strychnia.

TOXICOLOGY.

93. Strychnia causes the most intense muscular contractions, one especial feature being lockjaw. The patient dies either by asphyxia during one of the paroxysms or by exhaustion during a remission.

One-sixth of a grain is regarded as a fatal dose. Severe tetanus has been produced by one-twelfth of a grain. One grain is generally given as the poisonous quantity; on the other hand, a dose of twenty grains has been followed by recovery.

The symptoms may come on immediately; three and five minutes are also recorded; generally they appear in from ten to twenty minutes; they have been delayed an hour and longer. If the patient survives five or six hours, recovery is almost assured.

ANTIDOTES.

94. *First.*—Administer chloroform by inhalation to prevent lockjaw and enable you to use stomach-pump. Keep patient under influence for some time to moderate contractions.

Second.—Empty stomach as quickly as possible with stomach-pump, and wash it out two or three times at intervals of five minutes with water containing charcoal powder in suspension.

Use of opium, morphia, and camphor, and inhalation of oxygen are recommended.

95. The brief review we have given of the leading poisons will enable the student to master the various methods of manipulation required in testing for the presence of these bodies, at least for the purposes of diagnosis. When extended medico-legal examinations are required, the physician should not attempt them, but see that they are referred to a proper chemical expert.

For those who desire a further examination of the subject, reference may be had to the following works: Taylor's "Medical Jurisprudence," Woodman and Tidy's "Forensic Medicine," Wormley's "Micro-Chemistry of Poisons."

SECTION II.

WATER, H₂O.

96. A copious supply of potable water is one of the most urgent of the demands of the system. The great solvent power of this agent, taken in connection with the sources from which our supplies are obtained, render it peculiarly liable to become contaminated with substances more or less deleterious to the human economy.

FOREIGN SUBSTANCES IN WATER.

97. *First. — Gaseous.*—All natural waters contain oxygen and nitrogen, derived from the air. Water which has been boiled, and its normal supply of free gas thus expelled, and distilled water possess an unpleasant taste. In addition to O and N, the water of certain localities contains small traces of ammonia, carbonic acid, hydrochloric acid, salt, organic and inorganic dust also derived from the air.

The water of certain springs contains large proportions of carbonic acid gas and of sulphuretted hydrogen, derived from chemical changes taking place within the earth's crust.

Second. — Liquid.—Deleterious organic and inorganic liquids also find their way into our supplies of water; of these the most common is the sewage from house-sinks and waste materials from factories.

Third.—Solid.—May be in suspension or solution; they are either organic or inorganic.

The organic may be non-nitrogenized, or nitrogenized. The latter of these is the most dangerous of all the ordinary ingredients of natural waters, especially when it is capable of producing ammonia. The inorganic substances are chiefly silica, and different salts of potassium, sodium, calcium, magnesium, lithium, and iron.

SOURCES OF SUPPLY.

98. Rain-water which falls during the latter part of a storm is the purest of natural waters, since it can only contain substances derived from the air.

Water from melted snow and ice comes next in the scale of purity, since in the act of freezing under ordinary conditions water rejects the substances held in solution and crystallizes in a nearly pure condition.

Spring-water contains substances derived from the earth as well as from the air. According as the source of water in the spring is deep or superficial, so will it be wholesome or deleterious. Superficial or surface-water

springs contain more or less of organic matter. In deep springs, on the contrary, all organic matter has been oxidized by the action of air in the strata through which the water has passed. Such waters contain a greater percentage of inorganic substances, but these are, as a rule, less deleterious than the organic.

Wells may be connected either with underground flowing waters, or with stagnant accumulations; in the former instance the water is as pure as in springs, in the latter it is often exceedingly deleterious, especially is this the case when they are sunk in barnyards, in gardens, near privies, and sewers, or at a lower level than graveyards. The water from such sources is often a dilute solution of decaying humanity, or of the excreta of men and animals, and prone to favor the development of certain dangerous forms of fever.

In pools and marshes, the water being stagnant, organic matter which finds its way into them is not destroyed. Such water presents conditions favorable for the development of varieties of vegetable and animal forms which are deleterious. In this way the larvae of various entozoa also find their way into the bodies of animals. These waters should never be used for drinking or cooking purposes.

Lake and river waters, by their depth or by their movement, present conditions favorable for the destruction of organic matter. These are often very pure, and adapted for domestic use.

Ocean water and mineral waters are especially rich in inorganic salts, the latter are extensively used for medicinal purposes.

Water containing both organic and inorganic impurities may be beautifully clear and pellucid when freshly drawn.

EXAMINATION FOR ORGANIC IMPURITIES IN SOLUTION.

99. *First.*—Fill a bottle half full with water, and closing its mouth with a cork agitate it violently for two or three minutes. If the air in the upper part of the bottle possesses an unpleasant odor the water is not suitable for drinking purposes.

Second.—Water which has stood over night in a pitcher or other vessel, and then has a fetid odor is also unfit for use.

Third.—Place a pint or so of the water in a clean saucepan, or evaporating dish, and concentrate it down to one ounce. Fill a tablespoon or a capsule with this, and evaporate to dryness. If the water gives off an unpleasant odor during the evaporation organic matter is present, and if this is derived from sewage the odor is exceedingly offensive as dryness is approached. Incinerate the contents of the spoon, and the organic matter is destroyed, leaving a carbon residue which may be burned away. The relative proportions of the first residue and of the final ash afford the means of estimating the quantity of organic material.

The ash is to be examined according to 107.

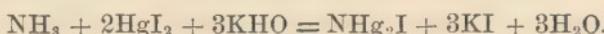
Fourth.—*The permanganate test.*—Place a measured portion of the concentrated water in a large test-tube, and the latter on a sheet of white paper. Add to the water one-sixth its bulk of strong H_2SO_4 . From a burette add solution of potassium per-



manganate of known strength. The solution is decolorized if nitrogenized organic matter is present. When the permanganate is no longer decolorized, as may be determined by looking downward through the fluid at the white paper, the amount used is to be read off, whence the comparative proportion of organic matter in the water may be estimated.

Fifth.—Test for nitrites.—These are found in water containing decomposing nitrogenized matter. Add to the concentrated water a few drops of dilute pure H_2SO_4 , then a little weak solution of iodide of potassium, and, finally, some starch mucilage. The deep blue iodide of starch is at once formed if nitrites are present. Nitrates do not act in this manner.

*Sixth.—*On adding Nessler's reagent to water containing exceedingly minute traces of ammonia, a yellow to a red coloration is produced. One part of ammonia in many millions of water may thus be detected. The reaction is as follows :

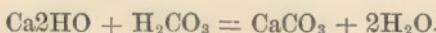


Nessler's reagent. This is prepared by dissolving 30 or 40 grammes of KI in a little hot water, adding strong hot solution of mercuric chloride, till the red mercuric iodide ceases to redissolve by heat and stirring, dilute, filter, add 180 grammes of caustic potash, and make up to one litre with water; about 5 c.c. of strong solution of mercuric chloride are added, the liquid set aside till it becomes clear, when it is decanted for use.

INORGANIC IMPURITIES IN SOLUTION.

100. While perfectly pure water has little or no action upon the silicates, carbonates, and other constituents of the rocks forming the strata from which springs flow, we invariably find that such waters contain more or less of these ingredients. A few simple experiments will demonstrate how the dissolving of these substances takes place.

*First.—*In a test-tube place 3 ij. of water with gtt. x. of lime-water, or calcium hydrate $Ca^{\prime\prime}2HO$; pass a few bubbles of carbonic acid gas through the mixture, or add a little strong solution of the gas in water, H_2CO_3 , at once a white precipitate of calcium carbonate is thrown down, the reaction being :



Calcium hydrate + carbonic acid = calcium carbonate + water.

*Second.—*Pass more of the CO_2 gas through the mixture, or add more of the H_2CO_3 , the precipitate gradually dissolves, the solution assuming a beautifully clear pellucid appearance, brighter than that of the purest water. We therefore find that calcium carbonate is soluble in water containing carbonic acid, and that



exceeding purity in appearance should lead us to suspect the presence of some compound of calcium.

Third.—Boil the solution obtained above; carbonic acid is expelled after a time, and the precipitate reappears.

101. All spring, well, lake, and river waters used for domestic purposes are derived originally from rain-water. In passing through the air the rain dissolves therefrom a certain portion of the CO_2 present. Thus the water passing into the earth is in a condition favorable for action upon the carbonates it contains. In like manner even the hardest silicates yield to water containing carbonic acid, and silica, one of the most insoluble of all substances, is brought into solution.

While rain itself contains carbonic acid, the quantity present is small compared with that produced in the water after it reaches the earth. In the superficial strata the water dissolves organic matter; in the deeper strata this is oxidized by the oxygen held in solution in the water, and so carbonic acid is produced in considerable amount.

HARD AND SOFT WATERS.

102. The presence of carbonates and sulphates of lime and magnesia give to water the property of producing a curdy precipitate with soap before a lather can be formed. Such waters are called hard, in contradistinction to rain-water and distilled water, which form a lather at once with soap. Hard waters are not well adapted for washing. They also form thick deposits on the interior of steam boilers, causing their tubes to burn away, and thereby lead to explosions. In the human economy, in like manner, they often lead to the production of calculi by the introduction of excess of inorganic material into the system.

Water may be either *temporarily* or *permanently* hard. In the first instance the calcium compound is a carbonate held in solution by carbonic acid, which may be expelled by boiling, and the CaCO_3 reprecipitated. In the second case it is a sulphate or some other form dissolved independently of the action of carbonic acid, and not reprecipitated by its expulsion.

Clark's soap test depends upon the formation of an insoluble lime soap, when a standard solution of soap in alcohol is brought in contact with water containing calcium compounds. The soap solution is added gradually from a burette to a known quantity of the water; the mixture is shaken after each addition until curd ceases to form, and a permanent lather is produced. The amount of soap solution used is read off, and the degree of hardness determined.

INORGANIC RESIDUE FROM WATER.

103. For a more thorough knowledge of the character of the inorganic constituents of a water, the student must be acquainted with the following reactions presented by silica, and also by potassium, sodium, and calcium compounds:

104. *First.*—*Potassium reaction.* Cleanse the platinum foil as in article 12. Place a small crystal of potassium chlorate in a

watch-glass, crush it to a powder, and moisten with a drop of HCl. Dip the foil into the mixture, and introduce it into the Bunsen flame, a momentary violet tint appears. Repeat the experiment until the eye is accustomed to the reaction. Viewed through the spectroscope a violet and a red bar are seen in the spectrum of such potassium flames.

105. *Second.*—*Sodium reaction.* Cleanse the foil, and repeat the experiment with sodium chloride. The flame becomes yellow, and through the spectroscope a yellow bar is seen.

106. *Third.*—*Calcium reactions.* Cleanse the foil, and place upon it a piece of chalk, CaCO₃, the size of a pin's head. In the flame the chalk will be seen to shine with a phosphorescent light, which is quite independent of a red-hot temperature. This phenomenon also appears in the case of magnesium, zinc, and a few other metallic compounds.

At first the calcium carbonate seems not to give a tint to the flame, but close inspection shows a faint yellowish red.

After the chalk has been kept in an incandescent state for two or three minutes, place it when cool on a slip of red litmus paper, and moisten it with water. The litmus will turn blue, showing an alkaline reaction.

Place a little powdered chalk in a watch-glass, add a drop or so of HCl; a brisk effervescence is produced by the escape of carbonic acid gas.

Dip the foil into this mixture, and on introducing it into the flame a bright red tint is seen, which, being examined through the spectroscope, shows red and yellowish green bands of calcium.

107.—Having become familiar with these reactions, apply them to the examination of the final ash obtained in article 99, *Third.* By the spectroscope the characteristic lines of potassium, sodium, and calcium may all be instantly detected if they are present. The undissolved residue left after the action consists almost entirely of silica, or silicic acid.

Examination for HCl, and H₂SO₄ acids contained in water must be conducted according to articles 69 and 70. For lead, see 51.

PURIFICATION OF WATER.

108. When the impurity is in a condition of suspension, it may be removed by filtration through layers of sand. Filters made of carbon may also be employed to advantage.

Hard waters in which the calcium is present as a carbonate may be largely freed therefrom by boiling. If the water is permanently hard, boiling is of no avail.

For the complete purification of water distillation must be resorted to. When such water is properly aerated, and a little common salt and solution of sulphate of lime and sulphate of soda added, it becomes very potable.

SECTION III.

ANIMAL FLUIDS.

109. The fluids of the body consist of certain organic substances, and salts dissolved or held in suspension in water. So long as the relative proportions of these are normal the fluid possesses a certain specific gravity or density. Any departure from this indicates a change in normal proportions of the ingredients, or the appearance of some abnormal substance in the fluid.

SPECIFIC GRAVITY.

110. For the determination of specific gravity the instrument called the hydrometer is used. According as it is graduated for the examination of alcohol, milk, urine, it is called an alcoholometer, lactometer, urinometer. A good urinometer is all that is required for the purposes of the physician.

In purchasing your urinometer, test it with water to determine whether the 0° of the scale is correctly placed. Avoid a very small instrument; select one graduated to single degrees. The divisions at the top of the scale should be farther apart than those at the bottom.

DIRECTIONS FOR USE OF HYDROMETER.

Hold the reservoir obliquely when filling it, to avoid foam.
Stand with your back to light or window.

Hold the reservoir by the top to insure perpendicular position.
Bring the top of the fluid to the level of the eye.

Read the scale by the lower sharp edge of the fluid.

Test your urinometer by the standard solutions of salt furnished for the purpose in the laboratory, and make a record of the errors found in different parts of the scale. Using these as corrections in future readings, a false urinometer may be made to serve as good a purpose as an accurate one.

111. Temperature exerts an influence on the indications of the urinometer. The following corrections should be made where accuracy is desired, as in the quantitative differential density test of sugar (172, *Fourth*).

TEMPERATURE CORRECTIONS FOR URINOMETER.

Temperature. F.	No. to be added to the indication.	Temperature. F.	No. to be added to the indication.	Temperature. F.	No. to be added to the indication.
60°.....	0.00	69°.....	0.80	78°.....	1.70
61°.....	0.08	70°.....	0.90	79°.....	1.80
62°.....	0.16	71°.....	1.00	80°.....	1.90
63°.....	0.24	72°.....	1.10	81°.....	2.00
64°.....	0.32	73°.....	1.20	82°.....	2.10
65°.....	0.40	74°.....	1.30	83°.....	2.20
66°.....	0.50	75°.....	1.40	84°.....	2.30
67°.....	0.60	76°.....	1.50	85°.....	2.40
68°.....	0.70	77°.....	1.60	86°.....	2.50

Proteids.

112. These are nitrogenized, organic substances, which enter into the composition of all the tissues and fluids of the body, with the exception of healthy sweat, tears, bile, and urine. They are all amorphous, except hemoglobin, and soluble in strong acids and alkalies, with decomposition. Some dissolve in water, their solutions possessing left-handed polarization.

Their composition, according to Hoppe-Seyler, varies

	O.	H.	N.	C.	S.
from	20.9	6.9	15.2	51.5	0.3
to	23.5	7.3	17.0	54.5	2.0

TESTS.

113. *First.*—Heated in a watch-glass with strong HNO_3 , the proteids become yellow; the addition of NH_4HO to this gives a deep orange tint.

Second.—Treated with solution HNaO , and a drop or so of cupric sulphate solution in a test-tube, they give a violet color, which becomes darker on boiling.

Third.—With Millon's reagent they give a precipitate, which, with the fluid, turns red on being heated. If only traces of a proteid are present no precipitate forms with the test, but the fluid turns red on being heated. In this manner $\frac{1}{100000}$ of albumen may be detected in an aqueous solution.

114. *Millon's reagent* is prepared by heating to 120° C . one part of mercury with two parts of nitric acid of sp. gr. 1.42. When the Hg is dissolved two volumes of water are added to one of the solution, and after standing for twenty-four hours the clear liquid is decanted and used for the test.

The proteids which especially command our attention are albumen, casein,

and fibrin. These are often called albuminous bodies; they present certain modifications to which the term albuminoid is applied.

Albumen.

115. Two varieties of this substance are described, viz., egg-albumen and serum-albumen or serin.

Egg-albumen may be prepared by breaking up the white of an egg, diluting with equal bulk of water, and shaking in a flask till it is frothy; after resting, the froth rises and carries the fibres with it. The fluid is then strained, dilute acetic acid added as long as it causes a precipitate, and the mixture filtered; the filtrate is neutralized.

Serum-albumen separates spontaneously from blood. It is the form which usually appears in the urine.

TESTS.

SIMILARITIES.

116. Egg-albumen.

Coagulated at 73° C.

Coagulated by strong HNO_3 .

Mercuric chloride precipitates does not coagulate.

Lead acetate precipitates does not coagulate.

Serum-albumen.

Coagulated at 73° C.

Coagulated by strong HNO_3 .

Mercuric chloride precipitates does not coagulate.

Lead acetate precipitates does not coagulate.

DIFFERENCES.

Rotation power over polarized light — 35.5° for yellow light.

Coagulated by ether.

Precipitated by HCl ; precipitate not readily soluble.

When coagulated is not readily soluble in strong HNO_3 .

Injected into the veins, or under the skin, passes unchanged at once into the urine.

Rotation power over polarized light — 56° for yellow light.

Not coagulated by ether.

Not so readily precipitated by HCl ; precipitate dissolves readily.

When coagulated is readily soluble in strong HNO_3 .

Injected into the veins, or under the skin, does not pass into the urine.

117. Either of these albumens treated with dilute acid, or with dilute alkali for a sufficient length of time, become converted into *albuminates*, known as acid-albumen and alkali-albumen respectively. In either of these conditions they are not coagulated by heat, but the whole of the proteid is thrown down when the solution is cautiously neutralized.

Casein.

118. In the pure state it is a white, friable, opaque substance. Soluble in dilute acids and alkalies, and reprecipitated on neutralization. Its reactions, therefore, resemble those of alkali-albumen. If potassium phosphate is



present in the solution, as is the case with milk, it must be made strongly acid before the casein precipitates.

Fibrin

119. Is insoluble in water. Soluble with difficulty in dilute acids and alkalies. It generally presents itself in the form of elastic filaments. If formed slowly in large masses, it loses the filamentous structure and resembles india-rubber. It imparts the property of spontaneous coagulation to blood and other fluids in which it is found.

Milk

120. Is the secretion of the mammary gland. It is white in color. In some animals it has an acid reaction, but in women it is alkaline.

AVERAGE COMPOSITION OF MILK.

	Woman.	Cow.
Water	889	865
Casein and extractive	40	55
Lactose or sugar	42	37
Butter or fat	27	36
Salts	2	7
	—	—
	1,000	1,000

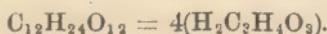
The larger proportion of casein and fat in cow's milk, and the smaller proportion of sugar, shows the necessity for the addition of water and sugar to make it a suitable diet for infants.

The specific gravity of normal cow's milk lies between 1,029 and 1,034. The removal of the fat causes a rise in the gravity. A rich specimen of freshly drawn milk with a gravity of 1,029 will show a gravity of 1,033 when the cream has been separated. By the addition of water the gravity may again be brought to 1,029, and thus the milk be made to appear as rich as at first; consequently, the lactometer alone is not a reliable test for the richness of milk.

121. Condensed milk offers a fair substitute for fresh milk when the latter cannot be obtained. It is prepared by adding white sugar to milk in the proportion of one ounce to the pint; the fluid is then concentrated to one-fifth in vacuum pans, and preserved in sealed cans. When opened, the contents of the cans keep better if a little is removed each day from the top. When used as a substitute for cow's milk, it should be diluted with four times its volume of water. For infants, this should be still further diluted, as in the case of cow's milk.

SPONTANEOUS CHANGES IN MILK.

122. Shortly after it is drawn from the gland the fat of milk separates spontaneously, and rises to the surface, forming cream. The reaction shortly afterward becomes acid, a portion of the sugar being converted into lactic acid by the splitting of its molecule.



The casein is then coagulated and forms the curd, which rests in a tawny fluid called the whey, which consists of the water, salts, and remainder of the sugar of the milk.

Lactic acid does not coagulate milk when cold, unless present in considerable quantity. Aided by heat, it coagulates the casein easily, as do other strong acids.

The sugar of milk, or lactose, acts toward the copper, or Trommer's test, in the same manner as grape-sugar, reducing the black to the red oxide.

TESTS.

123. Though the character of a specimen of milk can only be accurately determined by a troublesome and complete analysis, a proximate estimate of its richness and purity may be gained by the following methods :

First.—Determine the gravity. Any serious fall below the normal standard shows dilution with water.

Second.—Examine by the "pioskop." This little instrument consists of a round disk of hard rubber, two and a half inches in diameter, slightly raised toward the middle, with a shallow dish-like depression in the centre, in which a few drops of milk are placed.

This is then covered by a glass disk of two and a half inches diameter, transparent in the middle, the rim covered by six radial strips of oil-paint, varying from white to dark gray, and marked with the quality corresponding to it, from "cream" to "very poor milk."

The color of the thin layer of milk, as seen through the transparent part of the glass plate, corresponds with one of the six color strips, and its quality is determined at a glance.

Third.—Take a tube half an inch in diameter and ten inches high, graduated to one-hundredths, with the 0° a short distance from the mouth. Fill it to the zero with the milk to be examined, and let it stand vertically for twenty-four hours; then read off the percentage of cream in divisions of the scale. Normal cow's milk thus treated should give ten to fourteen per cent. of cream.

Fourth.—Dilute 10 c.c. of Fehling's solution (59) with 30 c.c. of water, and heat to boiling in a flask or capsule. Dilute the milk with exactly three times its volume of water, agitate thoroughly, place in a burette, and add gradually to the Fehling solution. The power of lactose to reduce copper is not as great as that of glucose, since it requires 67 milligrammes of the former to do the work of 50 of the latter. On this basis the percentage of lactose may be calculated.



IMPURE MILK.

124. Any great reduction in the proportion of lactose, without serious change in the gravity, tends to show that the milk has been diluted, and the gravity made up by the addition of some foreign material.

The milk secreted during the first few days contains colostrum; it is yellowish in color, with gravity from 1,040 to 1,060; it contains less lactose than milk, and its casein is replaced by albumen; therefore it coagulates when boiled.

The presence of colostrum and of pus in milk may be easily detected by the microscope; also that of starch, flour, and chalk.

Blood

125. Is a red fluid, having a specific gravity which varies from 1,045 to 1,075. It has a salty, unpleasant taste and a peculiar odor, which, by the addition of H_2SO_4 , is said to resemble that of the animal from which it is derived. The reaction of blood is alkaline.

In the living creature, blood consists of a fluid called plasma, in which corpuscles are floating. The corpuscles are of two kinds, white and red. The latter are derived from the former. They vary greatly in size and shape according to the kind of creature from which they are obtained, and those who are experts in such matters can generally tell by a microscopic examination from what source the blood has been procured.

According to C. Schmidt, human blood contains 513 parts of naturally moist corpuscles to 487 of plasma.

The plasma consists of water, holding in solution albumen, a small trace of fibrin, salts, fats, and extractive.

SPONTANEOUS CHANGES IN BLOOD.

126. Shortly after it is drawn the fibrin undergoes spontaneous coagulation, and the corpuscles being caught in its meshes a clot or coagulum forms. This floats in a tawny fluid called serum, which differs from plasma only in that it does not contain fibrin. The total amount of fibrin in blood is about 0.2 per cent.

The chief constituent of serum being albumen, the most interesting properties of that fluid depend mainly on its presence.

SPECTROSCOPIC EXAMINATION OF BLOOD.

127. The coloring matter of the blood is called *hemoglobin*. When purified and brought in contact with oxygen gas it forms a loose union therewith, and produces *oxyhemoglobin*.

When a solution of oxyhemoglobin, or of diluted blood, is placed between a source of light and the slit of a spectroscope, two dark bands appear in the spectrum between the lines D and E. Of these the narrower and darker is near to D, while the broader fainter band is near to E. The space between them is somewhat wider than the broad band.

If a little ammonium sulphide is added to a portion of the fluid under examination, the oxyhemoglobin is reduced to hemoglobin, the two bands disappear, and in their place a single broad band takes the place of the bright space of the oxyhemoglobin spectrum.

By the decomposition of hemoglobin *hematin* is produced. It may be prepared by shaking defibrinated blood with ether, to which a little glacial acetic acid has been added. When the ethereal solution separates, decant and filter into a test-tube, and examine with the spectroscope. It gives a wide absorption band in the position of the line C. In an alkaline solution the band at C disappears, and two bands, which merge into each other, appear between D and E.

TESTS.

128. *Coagulation test.*—Where pure albumen in solution has been coagulated by heat or by strong nitric acid, or by both agents combined, the precipitate is white, but if red blood corpuscles are present in the fluid, the coagulum assumes a chocolate color of varying shade, according to the proportion of disks present. Hence we have a test by which we may detect the presence of blood in serum, or in urine. It is as follows :

Add to the suspected fluid sufficient acetic acid to give it an acid reaction ; raise the temperature to the boiling-point. If blood is present, a dark coagulum is formed, and the liquid becomes clear, assuming its normal color.

Hemin test.—Place a drop of blood or a little hematin on a microscope slide, add a very small quantity of common salt and a drop of acetic acid. Warm gently, and examine from time to time under the microscope with a power of two or three hundred. As the fluid evaporates, the small, flat, rhomboidal, acute-angled crystals of hemin appear.

EXAMINATION OF BLOOD-STAINS.

129. *First.—By the microscope.* This requires a thorough knowledge of the appearances of the corpuscles under different conditions.

Second.—By the spectroscope. This is applicable when the corpuscles are disintegrated. The dry blood-stain on cloth, wood, etc., is digested with a small quantity of water containing a little ammonia ; the solution is filtered into a test-tube half an inch in diameter, and placed before the slit of the spectroscope, using sunlight and a very narrow slit. If the dark bands of oxyhemoglobin appear, no doubt can exist of the presence of blood.

If bands do not appear, acidify the ammoniacal solution with a little glacial acetic acid ; agitate the mixture with its own volume of ether ; aid the separation of the ethereal solution by the addition of a little more acetic acid if it is necessary ; place the ethereal solution before the slit of the spectroscope, when the dark, narrow band of hematin in acid solution will appear in the red at C.

Third.—Hemin test may be applied directly to the stain as fol-

lows: Transfer a portion to a microscope slide, rub it with a minute grain of NaCl, cover with thin glass, pass a drop of glacial acetic acid under the cover. After some ten minutes, warm very gently, and examine from time to time under the microscope. Conduct the process slowly, and if necessary add a second and a third drop of acetic acid and proceed as before (128).

Bile

130. Is the secretion of the liver. It has an alkaline reaction, a bitter taste, specific gravity from 1,026 to 1,032, color varies from green through a red or brown almost to black, it is viscid and froths when shaken.

The constituents of bile of greatest interest from a clinical point of view are its coloring matters and its salts.

Bile pigment.—In the bile of the carnivora and of man the golden red color is caused by *bilirubin*, $C_{16}H_{18}N_2O_3$. In the herbivora, the green tint is due to *biliverdin*, $C_{16}H_{18}N_2O_4$. The latter of these may be derived from the former by exposing an alkaline solution of bilirubin in a shallow vessel to the air, when it absorbs another atom of oxygen.

Bile salts are chiefly *sodium glycocholate* and *taurocholate*. In the bile of the herbivora glycocholate is in excess; in that of man and carnivora, taurocholate.

TESTS.

131. *First.*—For pigments. Gmelin's test. For this nitroso-nitric acid is required, which is nitric acid containing the lower oxides of nitrogen in solution. It may be prepared by exposing strong HNO₃ to sunlight till it turns yellow, or by diluting with HNO₃ the green liquid formed in the porous cell of a Grove battery.

Place about half an inch in depth of the acid in a test-tube, and holding the tube inclined at an angle of about 45°, pour a diluted solution of bilirubin on the surface of the acid to a depth of a couple of inches; the solution should float on the acid, not mix with it. At the point of contact green, blue, violet, red, and yellow tints appear in the order mentioned. Repeat the experiment, using a solution of biliverdin, a similar series of colors is produced beginning with the blue.

Another way of applying the test is to place a few drops of either of the solutions on a porcelain plate, and let a drop of nitroso-nitric acid fall in the centre, the colors appear in the form of concentric rings.

132. *Second.*—Bile salts. Pettenkofer's test. Pour the purified fluid containing the bile acids into a test-tube, add H₂SO₄ slowly in sufficient quantity to redissolve the precipitate; the mixture will be warm. Add a small piece of sugar or a little syrup; a series of colors is produced, passing from pink through red to purple. The purple color is the characteristic reaction.

The presence of a small quantity of albumen gives a reddish-violet reaction with this test which might lead to error, therefore, the necessity for purification.

133. *Cholesterin*, $C_{26}H_{44}O$, is another important constituent of bile; is also found in nerve-tissue, serum, excrements, pus, and dropsical effusions. It is tasteless, odorless, greasy, melts at 145° C., and out of contact with air sublimes at 360° . It is soluble in ether and in hot alcohol, from which it crystallizes in thin plates on cooling. It also dissolves in benzole and chloroform. Rubbed or triturated in a mortar with sufficient H_2SO_4 to moisten it, and then agitated with chloroform, a blood-red solution is formed, which, in contact with air, becomes violet, blue, or green.

Urine

134. Is the secretion of the kidneys, by which sundry results of retrograde metamorphosis in the system are conveyed out of the body in solution in water. It represents not only the results of the natural chemical changes, but also of those which are exceptional or abnormal. It is, therefore, best studied: 1st, in its normal, and 2d, in its abnormal state.

NORMAL URINE.

PHYSICAL CHARACTERS

135. *Color.* Is bright amber yellow. It varies from a pale yellow to a reddish-brown, according to the proportion of water and urinary pigments.

Condition. It is transparent, free from turbidity, and possesses the property of fluorescence.

Quantity. Varies from 40 to 60 fluid ounces, or from 1,000 to 1,500 cubic centimetres per diem. Is greatly increased in beer-drinkers, in hysteria, and in diabetes.

Specific gravity. Varies from 1,015 to 1,030 (110).

CHEMICAL CHARACTERS.

136. *Odor.* Is aromatic. Certain articles of food, as asparagus and cauliflower, give special odors, and also certain drugs, as cubeb and turpentine.

137. *Reaction.* Differs according as the urine is recently passed or not. If not more than one hour old it is *nearly always acid* (14), from the presence of acid phosphates of the alkalies. In rare cases it is alkaline immediately after a meal, or when alkaline or earthy carbonate have been taken. Salts of organic acids, i.e. (citrates, tartrates), with the alkalies, also give an alkaline reaction to urine, since they are converted into alkaline carbonates in their passage through the system.

If the urine has stood for a time, which varies with the temperature, it becomes alkaline by the decomposition of urea, which is its chief constituent. Under these circumstances am-

monium carbonate is produced, which imparts the reaction in question. It may be recognized by the ammoniacal odor.

If the alkaline reaction is produced by volatile alkali or ammonia, the litmus paper regains its red tint when dried. If by the fixed alkalies, the change in color to blue is permanent.

If it is possible, urine should always be examined before decomposition begins.

If urine has alkaline reaction from the presence of ammonium carbonate at the time it is passed, it is a serious pathological sign, indicative of inflammation of some portion of the mucous membrane of the urinary system.

COMPOSITION OF URINE.

138. The table gives the average quantity of each ingredient excreted during twenty-four hours, and also the percentage. From it we find that urea and chlorides are the chief solid constituents. It is, therefore, evident that variations in specific gravity of normal urine are chiefly owing to variation in these constituents.

CONSTITUENTS.	Grammes.	Per cent.
Total solids.....	60.0 to 70.0	4.3 to 4.6
Urea	30.0 to 40.0	2.5 to 3.2
Uric acid.....	0.4 to 0.8	0.03 to 0.05
Creatinine.....	0.5 to 1.0	0.036 to 0.062
Hippuric acid.....	0.3 to 1.0	0.02 to 0.06
Chlorides	10.0 to 13.0	0.7 to 0.8
Earthy phosphates	0.9 to 1.3	0.07 to 0.08
Phosphates.....	2.5 to 3.5	0.19 to 0.22
Sulphates	1.5 to 2.5	0.16 to 0.17

ABNORMAL URINE.

139. Urine may vary from its normal state in two ways: 1st, by change in the proportion of one or more of the constituents; and 2d, by appearance of new or abnormal ingredients.

VARIATION IN NORMAL INGREDIENTS.

140. It is understood that all determinations in relation to variations in the normal ingredients are to be made on the urine of the whole day of twenty-four hours. Examination of a single specimen is of little or no value. The urine must be passed into a vessel of sufficient capacity to hold the whole quantity passed, say from 7 A.M. of one day to 7 A.M. of the next. This should be measured and a sample examined, when valuable indications may be obtained regarding the rate and manner in which chemical changes are taking place in the system.

UREA OR CARBAMIDE, CON_2H_4 ,

141. Is the chief constituent of the urine. It is also found in the blood, and when its removal by the kidneys is interfered with, it appears in all the fluids of the body. It is crystalline, very soluble in water, and deliquescent. It was one of the first of the organic bodies which was made artificially.

Increase in the diurnal quantity appears: 1st, with increase in the amount of animal food; 2d, in acute febrile actions; 3d, in the different forms of diabetes.

Diminution arises: 1st, during fasting; 2d, during the use of a vegetable diet; 3d, in certain chronic diseases or (cachexies); 4th, in parenchymatous nephritis, especially on the approach of death.

No special characteristics of color, condition, quantity, odor, or reaction attend variations in the proportion of urea in urine.

TESTS.

142. *Examination for excess:* 1st, the specific gravity is over 1,030; 2d, place 1/3 j. of the urine in a test-tube, add one-third its bulk of strong colorless HNO_3 , and keep the tube at 32° F. or 0° C. , by setting it in a mixture of ice and water. If the high gravity is owing to an excess of urea, scale-like crystals of the nitrate will be formed.

If there is effervescence on adding the HNO_3 , it is generally owing to the escape of CO_2 from ammonium carbonate produced by the decomposition of the urea. The presence of the lower oxides of nitrogen in the HNO_3 will also cause an evolution of gas.

143. *Examination for diminution:* 1st, the specific gravity is below the average normal; 2d, the amount of diminution may be ascertained by finding how much concentration is required before the specimen yields urea-nitrate crystals when examined as described above.

144. *Absolute quantitative determination.*—The modern methods are based on the fact that nitroso-nitric acid, hypochlorite or hypobromite of sodium decompose urea into water, nitrogen, and carbonic acid. The quantity is measured either by measuring the volume of gas disengaged, or by weighing the carbonic acid, as barium carbonate.

Liebig's volumetric process consists in the precipitation of the urea by pernitrate of mercury. It is not reliable, since the precipitate varies in the proportions of its ingredients.

URIC ACID, $\text{C}_5\text{H}_4\text{N}_4\text{O}_8$,

145. Occurs in the urine of all carnivorous creatures. It requires 15,000 parts of cold water to dissolve it. Only a small part is present in the free state in urine, the greater portion being urates. Like urea, it represents retrograde metamorphosis of nitrogenized tissue, and is supposed to be an intermediate step in the series of changes of which urea is the final result.

It may be prepared from urine, by adding one part of HCl to about thirty of urine, and letting it stand in a cool place for twenty-four hours ; the uric acid then crystallizes, and the sediment may be separated by decantation, and washed on a filter (5). Thus prepared uric acid is red ; it is the so-called brick-dust sediment of urine. In its pure condition it is white.

146. *Increase in diurnal quantity appears* : 1st, in over-feeding ; 2d, lack of sufficient exercise ; 3d, acute febrile actions ; 4th, disease of heart or lungs attended by dyspnoea ; 5th, where tumors or accumulations in the abdominal cavity interfere with the action of the diaphragm ; 6th, in leucæmia ; 7th, in the uric acid cachexy.

Excess of uric acid is generally attended by increased depth in the tint of the urine, and a strongly acid reaction ; sometimes a turbidity and formation of red sediment or crystals in a few hours.

The quantity is sometimes scanty ; gravity and odor do not present any special characteristics.

Decrease occurs in chronic disease of the kidneys, diabetes mellitus, hydruria, and arthritis.

TESTS.

147. *Heat*.—Examined on platinum foil in the Bunsen flame, uric acid gives off the odor of burning hair, and leaves a residue of carbon, which may be completely burned away ; thus it is shown to be a nitrogenized organic body.

148. *Murexid test*.—Place a little uric acid in a watch-glass, add two to five drops of strong HNO₃, warm over a flame ; the uric acid dissolves. Evaporate very cautiously to dryness, a red residue remains. With NH₄HO, this gives a purple red ; with KHO a violet blue, which is evanescent.

Increase or diminution may be estimated by treating a normal specimen, and that to be examined, in equal quantities in test-tubes with HCl, and after twenty-four hours noting the amount of uric acid sediment formed.

CHLORIDES.

149. Next to urea the chlorides are found in largest quantity in normal urine. They consist of common salt, NaCl, with a little calcium chloride. It is the presence of NaCl which gives to urine its salty taste. A drop of normal urine evaporated to dryness on a microscope slide, leaves crystals of NaCl easily recognized, when placed in the field of that instrument.

Though the chlorides in the urine are taken in that form in the ingesta, and are not produced in the system, they nevertheless show considerable changes in amount under certain conditions of disease.

150. *Increase* is found : 1st, with the free use of salt provisions ; 2d, energetic physical or mental exertion ; 3d, during paroxysms of intermittent fever, or just before or after ; 4th, in diabetes insipidus ; 5th, in dropsy when diuresis intervenes.

151. *Decrease* : 1st, during repose ; 2d, in acute febrile and inflammatory

actions, the chlorides then appear in such exudates as pleuritic effusions, diarrhoea, etc.; 3d, in chronic diseases attended by dyspepsia, and in dropsy.

As a rule, the chlorides diminish as the disease intensifies, and increase as it relaxes. Their absence indicates a very desperate state. In pneumonia they may disappear entirely.

The color, condition, quantity, gravity, odor, and reaction of the urine do not present any special characteristics with change in proportion of chlorides.

TESTS.

152. In article 70, *Fifth*, the reaction between nitrate of silver and a compound of chlorine is described. In the urine, phosphates are present as well as chlorides (138). Phosphates also produce a precipitate with argentic nitrate, providing the solution is not acid. To avoid any error in testing for chlorides, the urine should be first acidified with HNO_3 , and then agitated. All the precipitate that then forms on the addition of AgNO_3 solution is due to the presence of chlorides, and is curdy in its character.

By testing the specimen to be examined against a normal specimen in a companion-tube, any variation in the proper quantity is quickly detected. The determination may be made still more satisfactory by testing the specimen against a solution of NaCl in water of the same proportion as that given in the table, article 138, *i.e.*, .8 per cent.

Accurate volumetric determination of the chlorides by the use of a standard solution of silver nitrate may be made by adding a few drops of potassium chromate to the urine. The red silver chromate begins to be thrown down as soon as all the chloride is precipitated, and before any phosphate forms. The amount of silver solution employed up to the formation of the red precipitate is the measure of the quantity of chloride present.

PHOSPHATES.

153. The forms under which these are found in the urine are as acid phosphates of sodium, magnesium, and calcium. The sodium salt is soluble, but the others are held in solution by the acid reaction of the urine; they are precipitated when it becomes alkaline.

The proportion of phosphates in urine is greater during the day.

154. Increase in phosphates is found: 1st, after the ingestion of phosphorus, phosphoric acid, and soluble phosphates; 2d, after an animal diet, especially of brain; 3d, in acute febrile diseases; 4th, in diseases of the bones and rheumatism; 5th, after the use of mineral waters rich in carbonates; 6th, after any exhausting nervous action, as over-study and excessive venereal indulgence, also paroxysms of grief and of joy.

155. Decrease is found: 1st, in low gravity urine; 2d, in diseases of the kidney and heart; 3d, in dyspepsia.

The color, condition, quantity, gravity, odor, and reaction of urine containing excess of phosphates do not present any fixed characters when freshly passed. In a short time it often assumes a turbid state, owing to the precipitation of the earthy phosphates.

TESTS.

156. When urine containing excess of phosphates is heated, a precipitation takes place, since these are more insoluble in hot than in cold water. This precipitate closely resembles that produced by albumen under the same conditions. It differs in that it readily dissolves on the addition of a few drops of HNO_3 , while the albumen precipitated is insoluble, and may even increase in quantity when HNO_3 is added.

157. A satisfactory approximate estimate of the total amount of phosphates in urine may be obtained by the following method : In a test-tube place a column of urine four inches in depth, add a few drops of KHO, enough to give a strong alkaline reaction ; raise the temperature to the boiling-point, and set the tube aside for fifteen minutes, to allow the precipitate to settle. Thus treated, urine containing the normal proportion of phosphates will give a precipitate about half an inch in depth. Any great departure from this indicates the extent of the increase or diminution in proportion of this ingredient.

SULPHATES

158. Occur as sodium and potassium sulphates. They are derived either directly from the ingesta or from disintegration of the proteid compounds of the system. They therefore become an indication of the rate at which metamorphosis is taking place in the organism, and especially in the muscular tissue.

159. *Increase* in proportion of sulphates appears: 1st, after the ingestion of sulphur, sulphuric acid, and soluble sulphates ; 2d, from increased consumption of flesh or albuminous food ; 3d, in acute inflammation attended by increase in amount of urea, as meningitis, encephalitis, and muscular or articular rheumatism.

Decrease appears with the diminished use of albuminous food, at the outset of typhus fever, and generally in urines of low gravity.

The general physical and chemical properties do not show any special characteristics.

TESTS.

160. The reactions of H_2SO_4 and BaCl_2 have been explained in article 70 (*Fourth*). It happens that phosphates also give a precipitate with BaCl_2 solution. To prevent this, a little pure HCl must be added to the urine before it is tested with the BaCl_2 solution.

Normal urine gives an opaque, milky appearance when tested in this manner. The eye should be trained to the intensity of the whiteness by the examination of a number of normal specimens. Any departure from the ordinary test will then give a proximate indication of an increase or a diminution in the sulphates.

Abnormal Constituents.

ALBUMEN

161. Is not a normal constituent of the urine. It sometimes appears temporarily. When it is present continuously, it generally indicates serious pathological change.

It appears: 1st, from the inordinate use of egg-albumen; 2d, when the blood-pressure in the kidney vessels is greater than the normal, as in obstructed venous circulation; 3d, in changed conditions of the diffusion membranes of the kidney, *e.g.*, Bright's disease; 4th, when pus, blood, or other albuminous fluid is present in the urine; 5th, in changed condition of the blood-albumen.

Generally the color of albuminous urine is lighter than the normal; the specific gravity is usually low—1,004 to 1,025—but Roberts gives a case in which it was 1,065. The other general, chemical, and physical characters present no special points of interest.

TESTS.

The different forms of albumen and their reactions have been discussed in Articles 115, 116, 117. For the detection of albumen in the urine, the heat-test and that by HNO_3 are generally employed.

162. *Heat-test.*—Add sufficient acetic acid to give an acid reaction, then boil. A flocculent precipitate indicates the presence of albumen.

Unless acetic acid is added, a precipitate of phosphates may form; too much acetic acid may prevent the precipitation of albumen. On the other hand, in alkaline urine, heat alone may fail to precipitate albumen, unless the urine is rendered slightly acid, as directed.

163. *Nitric acid test* is described as follows, in the translation of Hoffmann and Ultzmann's work by Brune and Curtis:

"For the HNO_3 test, 10 c.c. of urine should be taken in a wine-glass, and then pure, colorless, concentrated HNO_3 (not fuming) should be allowed to flow down the side of the glass, forming a layer beneath the urine. Now, if albumen is present, a white zone will appear between the two fluids. This can only be confounded with the urates, which are precipitated in a somewhat similar manner when present in great amount; also with the resin of copaiva. In the case of the urates they are not precipitated in the zone between the fluids, but somewhat higher up, and are not sharply defined as a zone, but curl upward from the centre, having the appearance of ascending smoke."

164. If albumen and much urates are present in a urine at the same time, we obtain by the nitric acid reaction two layers, one above the other. The lower layer, sharply defined above and

below, between the colorless acid and the urine, is the albumen. The upper layer, gradually becoming more intense and not sharply defined above, but ascending as a white cloud, consists of the urates. A layer of clear urine separates these two. The layer produced by the resin of copaiva disappears on the addition of a few drops of alcohol.

"165. If we apply the nitric acid test to normal urine, we observe between the acid and the urine a brown ring of urine coloring matters, which in a few minutes becomes more voluminous. In febrile processes, when the urine contains much coloring matter, this ring is very intensely colored. As albumen when present appears in the same zone, this does not form now as a white layer, but is more or less tinged with brown. If much indican is present, the urine often appears a beautiful rose-red or even violet ; from the presence of blood-coloring matters, brown-red ; from undecomposed bile-coloring matters, a beautiful green. If a urine is strongly concentrated and we add HNO_3 , a copious crystalline precipitate of nitrate of urea falls, which, under the microscope, shows the characteristic colored rhombic tables. From a urine rich in uric acid we often see beautiful, shining, light yellow-colored whetstone crystals, which can be easily distinguished microchemically from nitrate of urea, because they are not soluble in water.

"166. If the urine contains much carbonic acid, either because it is alkaline and contains much ammonium carbonate, or because it has a neutral or even acid reaction, and contains much sodium carbonate or free carbonic acid (as is the case from use of alkaline and carbonated mineral waters), we observe that the fluid, by addition of HNO_3 , becomes sparkling and sometimes even effervescent."

BLOOD

167. May appear in the urine by hemorrhage from the large vessels, by capillary hemorrhage, or from a breaking down of the blood-corpuscles. The color of such urine presents various shades of brownish-red.

TESTS.

168. *First.*—As albumen is present in all cases of hemorrhage, it is precipitated by heat (128). The dark precipitate, and clearing up of the urine, which assumes the normal color, causes the presence of blood to be suspected. To complete the demonstration, collect the coagulum on a filter, dry, extract with alcohol containing a little H_2SO_4 , evaporate the solution to dryness and apply the hemin test.

Second.—Blood-coloring matter may also be precipitated by adding a little KHO to the urine and raising the temperature



short of boiling ; the phosphates are then precipitated, and, carrying down the coloring matter with them, appear of a blood-red color. If the coloring matter is small in amount, the precipitate is dichroic in appearance. Collect the precipitate upon a filter, dry, and apply the hemin test as follows :

Warm a little of the precipitate upon a microscope slide until it is quite dry ; rub a few fine grains of NaCl into the residue, lay a hair on the mass, cover with thin glass, and conduct the operation as in 129, *Third*.

BILE.

169. In certain conditions of the liver the constituents of bile make their appearance in the urine. In this case the color of the urine changes to different shades of yellow to brown. It makes yellow stains on the clothing ; it also acquires a bitter taste. The other general properties are variable.

- TESTS

170. Are particularly confined to the detection of the coloring matters of bile, that is, to Gmelin's test, as described in article 131, substituting the specimen of urine for the dilute solution of bilirubin.

The test may also be made by floating the urine over a layer of ordinary HNO₃ in a test-tube, and then introducing H₂SO₄, while the tube is held in an inclined position, the heavy H₂SO₄ sinks beneath the HNO₃, and the colors make their appearance as when nitroso-nitric acid is used, *e.g.*, green, blue, violet, red, yellow, from below upward ; the green being the chief and the blue sometimes wanting.

The use of Pettenkofer's test requires a troublesome process of purification to make its application reliable. It may, however, be applied directly to the urine as an adjunct to Gmelin's test.

SUGAR.

171. By some, sugar is regarded as a normal constituent of the urine. Admitting that such may be the case, the quantity is exceedingly small. The form in which sugar is present is that of glucose or diabetic sugar, constituting the disease called diabetes mellitus ; the quantity may exceed 100 grammes to the litre.

Diabetic urine is generally of a light color, and has a high gravity, though sometimes it is very low. The quantity is more than double the ordinary average ; it has reached twenty litres. It is sweet to the taste, and if evaporated on a piece of cloth, leaves a sticky stain like honey. It has a whey-like odor.

TESTS.

172. Should the urine contain albumen, the albumen must be separated by acetic acid and heat before applying the tests.

First.—Trommer's test. Add to some of the urine, in a test-

tube, a few drops of solution of sulphate of copper, then add solution of caustic potash in excess; boil the mixture. If it contains sugar, the yellow or red suboxide of copper precipitates. If it does not contain sugar, the precipitate is blue or black. *Care must be taken not to use an excess of the copper solution.* See articles 57 and 58 for sources of error and cautions.

Second.—Moore's test. Add an excess of KHO to the urine and boil; a lemon-yellow, yellowish-brown, or a blackish-brown color appears. Treated with a little HNO₃, the color is destroyed and an odor of molasses produced.

Third.—Fermentation test. Add to the urine a little fresh yeast or a few grains of yeast-cake, and set aside for twenty-four hours at a temperature of 70° to 80° F. The sugar undergoes fermentation, alcohol and carbonic acid being produced. The white scum which appears during the fermentation shows the torula cells when examined under the microscope.

Fourth.—Quantitative differential density test.—Take two vessels, place in them enough of the urine to fill the urinometer reservoir. To one of the vessels add a little yeast-cake, determine the specific gravity of both, and set aside for twenty-four hours to ferment. Again take the specific gravity. Every degree of specific gravity lost in the yeast mixture is equal to one grain of sugar per fluid ounce of urine. Any variation of specific gravity, owing to change of temperature or other cause, will be shown by the companion vessel, and should be allowed for.

Fifth.—Fehling's quantitative test may be applied according to article 59.

Trommer's and Fehling's tests are liable to error, since uric and hippuric acid, and the urates, if in large quantity, cause a reduction of the copper oxide. The most reliable tests in doubtful cases are those by fermentation and polarization.

EXAMINATION OF LIQUID URINE.

Name.	Color.	Reaction.	Sp. Gr.	Heat.	HNO ₃ .	Other tests.
Ammon. Carb. Urea, excess of	Varies "	Alk..... Varies....	Varies. High..	..... .....	Effervesces. Crystals of urea nitrate. }	Crystals with oxalic acid.
Sugar .....	"	" ....	" ..	.....	.....	Trommer's and fer- mentation tests.
Phosphates...	"	"	Varies.	White ppt.....	Ppt. dissolves..	Ppt. with heat. Sol- uble in HNO ₃ .
Albumen	"	"	"	"	White ppt	Mercuric chloride, tannic acid, etc.
Bile	"	"	"	" often	Colored ppt....	Gmelin's test.
Blood	Brown	"	"	Dark ppt.....	Dark ppt	Microscopic exami- nation. Iron test.
Chyle.....	White	"	"	White ppt.....	White ppt	Separation of fat by ether.

SECTION IV.

SEDIMENTS AND CALCULI

173. Consist of unorganized or organized substances, which are eliminated from the blood, or deposited from the fluids of the body. They are gouty concretions, salivary concretions and tartar, gall-stones, and urinary sediments and calculi.

GOUTY CONCRETIONS

174. Are nearly white, soft, and friable, are often called chalk-stones. They appear in the joints of persons suffering from gout. Their composition varies greatly, but is made up chiefly of an acid urate of soda, with chloride of sodium and dry epithelium, sometimes they contain urate and phosphate of lime and chloride of potassium. *The presence of the uric acid may be shown by the heat and murexid tests (147, 148).*

SALIVARY CONCRETIONS AND TARTAR.

175. The solid constituents of the saliva are deposited occasionally as small concretions in the ducts of the salivary glands, and commonly upon the surface of the teeth, forming the coating known as tartar. The deposit consists in both instances of carbonate and phosphate of calcium, with some albuminoid body.

Submitted to the action of dilute HCl, the mineral matter dissolves with effervescence, owing to the escape of carbonic acid. The residue is the albuminoid or organic substance.

BILIARY CALCULI

176. Are found in the gall-duct, gall-bladder, and in the intestines. They are sometimes nearly an inch in diameter, and nearly spherical in form. The color is a light brown ; they are greasy, quite soft, and easily cut or crushed. They are formed almost entirely of cholesterin, with a little bile pigment and inorganic matter. The structure in section is radiating. They sometimes exhibit concentric layers.

The cholesterin may be extracted and examined according to 133. The residue may be examined with dilute HCl, as in article 175.

URINARY SEDIMENTS.

177. When freshly passed, normal urine is clear, but after standing for a short time, a cloud appears in the lower part of the fluid ; this is mucus from the urinary passages. It is best seen by holding the vessel against a dark surface. If the vessel has been carefully cleansed, the urine may remain therein for a long time, weeks even, without further change ; commonly, however, it undergoes the so-called

178. *Acid fermentation.*—This is produced by the action of the phosphate of sodium upon the sodium urate of the liquid. From this, at low temperature, an acid salt of uric acid results, which is quite insoluble and forms a yellowish-red sediment, the reaction of the urine becoming very acid. At higher temperatures the whole of the sodium is abstracted from the urate, and a crystalline deposit of uric acid is produced which is brick-red ; sometimes it adheres to the sides of the vessels, and sometimes it floats on the surface of the fluid. Crystals of oxalate of lime are often seen mingled with this sediment.

179. *The alkaline fermentation* follows upon the preceding, the urine becomes of a lighter color, the uric acid disappears, the reaction becomes neutral, then alkaline, an ammoniacal odor is given off, clearness gives place to turbidity, and a whitish sediment forms, which contains ammonium urate, amorphous calcium phosphate, and triple phosphate or phosphate of magnesium and ammonium. Under the microscope the turbidity is seen not to consist of suspended phosphates, but of innumerable bacteria, some quiet, some in perpetual movement. This change is the result of the action of a peculiar ferment upon the urea.

If the vessel in which the urine is placed is unclean, and especially if soiled with fermented urine, the decomposition is rapid, the acid fermentation does not occur, but the alkaline sets in at once.

180. In abnormal urines, the substances are diffused throughout the fluid when it is first passed, making it more or less turbid ; after a time they subside and form sediments. All urinary sediments may be grouped as unorganized and organized ; the first may be either amorphous or crystalline. They have been classified as follows by Hofmann and Ultzmann :

SEDIMENTS CLASSIFIED.

A. NOT ORGANIZED.

a. *Amorphous.*

From acid urine.

1. Urates of sodium and potassium.
2. Fat.

From alkaline urine.

1. Calcium phosphate.
2. Calcium carbonate.

<i>From acid urine.</i>	<i>b. Crystalline.</i>	<i>From alkaline urine.</i>
1. Uric acid.		1. Ammonium urate.
2. Calcium oxalate.		2. Triple phosphates.
3. Cystine.		3. Calcium phosphate.
4. Tyrosine.		4. Magnesium phosphate.

B. ORGANIZED.

1. Mucus and pus-corpuscles.
2. Blood-corpuscles.
3. Epithelium from the various tracts of the urinary apparatus.
4. Cylinders (or casts) and fibrin coagula.
5. Spermatozoa.
6. Parasites and entozoa.
7. Extraneous objects.

In this series the constituents are arranged according to their form and the frequency of their occurrence, excepting the last.

Sediments may be examined in three ways : 1st, by suspending them in the urine by agitation ; 2d, by transferring them by a pipette in the concentrated state to watch-glasses or test-tubes ; 3d, by collecting them upon filters.

It is always well to make a preliminary examination of all sediments and calculi, by the heat-test described in article 12 ; we thus learn, at the outset, whether the substance is organic or inorganic, and if it is a mixture of both, in what proportions they are present. The sediment should be dried.

EXAMINATION OF SEDIMENTS.

The following systematic course is partly from Bowman's "Medical Chemistry" and partly from Hofmann and Ultzmann :

UNORGANIZED SEDIMENTS.

181. *Urates.*—Transfer a little of the deposit to a test-tube by means of a pipette, add some of the urine, shake the tube to diffuse the sediment through the liquid.

First.—WARM THE MIXTURE ; IF THE SEDIMENT DISSOLVES, IT IS PROBABLY URATE OF SODA OR AMMONIA.

These form the most frequent and unimportant of urinary sediments. Slight concentration of the urine from increased perspiration, and slight febrile actions will cause a sediment when the urine cools. The color varies from white to pink and red. The milky urine of infants is of this nature.

Second.—Place another portion of the sediment in a tube, add a drop or so of hydrochloric or of acetic acid. Crystals of uric acid will form.

Third.—Collect some of the deposit upon a filter, dry it, and examine by heat and the murexid tests (147 and 148) for uric acid.

As is shown in the table of sediments, if the urine is acid, potassium and sodium salts are present. They may be differentiated by the flame tests and spectroscope (104, 105). If the urine is alkaline, urate of ammonia is present.

182. Phosphates.—IF THE DEPOSIT DOES NOT DISSOLVE WHEN WARMED, add to a few drops of the sedimentary urine, in a test-tube, a little acetic acid.

IF THE DEPOSIT DISSOLVES IN ACETIC ACID, it probably consists of EARTHY PHOSPHATES, the nature of which, whether consisting of phosphate of lime or triple phosphate, or a mixture of both, may be distinguished by submitting a little of the deposit to microscopic examination. The phosphatic precipitate may be made to reappear on adding either volatile or fixed alkali.

183. Oxalates.—IF THE DEPOSIT PROVES INSOLUBLE IN ACETIC ACID, test another portion with a little dilute hydrochloric acid. If it DISSOLVES IN THE ACID, and the acid solution thus obtained gives, when neutralized with ammonia, a white precipitate, it is probably OXALATE OF LIME. Oxalate of lime dissolves without effervescence. If there is escape of CO_2 , and no precipitate on adding NH_4HO in dilute solution, the sediment is calcium carbonate.

184. Uric acid.—IF HYDROCHLORIC ACID FAILS TO DISSOLVE THE DEPOSIT, it may be tested for URIC ACID by means of nitric acid and ammonia (147 and 148). Uric acid may also be readily distinguished under the microscope.

185. Mixed deposits.—If the deposit does not consist of earthy phosphates, uric acid, urate of ammonia, nor oxalate of lime, it must be examined for the other matters which are occasionally, though less frequently, met with in morbid urine. It must be remembered that, in the majority of cases, urinary deposits do not consist *exclusively* of any one substance, but contain two or more mixed together, as when the earthy phosphates occur associated with an excess of mucus. The action of the several tests may in this way be more or less masked, and, when taken alone, may lead to erroneous conclusions. In such cases the microscope will be found of infinite value, and should always, when available, be employed.

186. Where such an intermingling of unorganized deposits exist, they may be found by filtering off the solution formed by each solvent. After the urates have been dissolved by heating, the undissolved portion of sediment may be collected on a filter. When the fluid has drained away, the contents of the filter may be washed into a test-tube and examined by acetic acid for phosphates. The dissolved phosphates having been filtered off, the remaining sediment may again be separated and examined for oxalates by HCl. In its turn, the sediment from this operation may be examined for uric acid. In the majority of cases decantation is preferable to filtration.

ORGANIZED SEDIMENTS.

Chemical tests are not, as a rule, available for detecting the nature of these deposits. The list is given to advance the student's knowledge of the subject.

187. Pus.—If the deposit sinks readily to the bottom of the vessel, forming a PALE GREENISH-YELLOW SEDIMENT, which, on agitation, is again diffused readily and uniformly throughout the liquid, it probably consists of PUS. Confirm by examination with the microscope for the characteristic corpuscles.

188. Mucus.—If, on the other hand, the deposit is TENACIOUS AND ROPY, not mixing uniformly with the liquid when shaken, it probably represents an excess of MUCUS.

189. Blood.—If the deposit is DARK-COLORED, brown, or red, and has been found not to consist of urate of ammonia colored with purpurine, it probably contains BLOOD; in which case the clear portion of the urine will give indications of albumen when heated, or when tested with nitric acid. Confirm by 168.

190. Cystine.—When the deposit is WHITE OR NEARLY SO, having proved insoluble when warmed, and also when treated with dilute hydrochloric and acetic acids, and is found to be readily SOLUBLE IN A SOLUTION OF AMMONIA, the ammoniacal solution yielding on evaporation HEXAGONAL CRYSTALLINE PLATES, it is probably CYSTINE.

191. Fat.—If, when a little of the urine is agitated with half its bulk of ether in a test-tube, and the ethereal solution, after separating from the watery portion on which it floats, is found to leave, after evaporation at a gentle heat, a residue of fat or oily matter, the presence of FAT may be inferred. The detection of fat is to be regarded with caution, since it may have come from lubricants used in the introduction of a catheter or other instrument. In the case of the following comparatively rare disease, it is, when taken with the color, quite characteristic :

192. Chyle.—If the urine is OPAQUE AND ALMOST MILKY in appearance, yielding traces of fat when treated with ether, and is found, when examined under the microscope, to contain an abundant white amorphous or granular deposit of albumen or fibrin, together with small, round, colorless corpuscles, it probably contains CHYLOUS MATTER.

193. Epithelium and casts.—The former from all parts of the urinary tract, and the latter from the tubuli uriniferi, are only to be found by microscopic examination. In the urine of women, epithelium from the generative organs is generally present.

194. Spermatozoa.—Are only discoverable by the microscope. They appear with a strong power as small, rounded forms, with a longer or shorter hair-like tail. One seldom has an opportunity of seeing them in motion in the urine. A urine which contains spermatozoa often shows white, cloudy flakes, which, under the microscope, are resolved into a mass of spermatozoa, imbedded in a finely granulated substance. Since spermatozoa are very light, they require several hours to settle. After six to twelve hours we find, besides the flocculent lumps, isolated seminal granules. On account of the resisting capability of these structures, they may be found in the urine after several days.

Spermatozoa are found :

First.—After coition, nocturnal pollution, etc., when a part of the semen remains behind in the urethra and is washed out later by the urine.

Second.—With spermatorrhœa.

We also observe involuntary emissions in typhus.

In the urine of women we find spermatozoa after coition—a fact which may have great medico-legal importance.

195. Parasites.—First, bacteria, regarded by some as plants, by others as animals. The urine is always cloudy, even after the sediment settles. The account of the following forms is taken from the work of Hofmann and Ultzmann :

a. The monad forms. These are round, punctiform bacteria, which either remain quiet or show a quivering motion. One must exercise care not to confound with these the earthy phosphates which have a molecular movement. While the movement of a lifeless structure goes on in one place, the monad forms of bacteria change their position in the field of the microscope.

b. The rod forms. These are very small rods, scarcely the diameter of a blood-corpuscle, and immeasurable in thickness. Both ends are generally swollen and knob-formed. They are sometimes at rest, and sometimes moving through the field.

c. The vibriones. These are made up of the above-mentioned forms—two or more rod-like bacteria, one hanging on to another, moving sometimes spirally and sometimes with a motion resembling that of a fish's tail, going hither and thither with great rapidity.

d. The hair forms, or chain forms. These are long, often reaching across the entire field, and are to be distinguished only by their length from the vibriones. Only with a very high magnifying power can their jointed composition be recognized. They move but seldom, and then very sluggishly, in the manner of a serpent.

e. The zooglöa forms. These appear as masses of punctiform bacteria held together in a common gelatinous mass, resembling a precipitate of earthy phosphates held in mucus.

All these forms may be observed in the same urine and often under the same cover-glass.

Second.—The yeast plants (*Saccharomyces urinæ*).—These are single vesicular cells, of the size of blood-corpuscles, and of somewhat oval shape. Usually, however, they are made up of small cells arranged like a rosary, some of the beads having two or three bud-like cells attached. This fungus appears in much less quantity than the bacteria, and is found mostly in acid urine on a warm day. This plant has the greatest similarity to the yeast plant of beer (*Saccharomyces cerevisiae*), without being identical. In diabetic urine this form occurs, but more vigorously developed.

Third.—*Sarcina*.—This form has the greatest similarity to *Sarcina ventriculi*, but is appreciably smaller. They are arranged in groups of two, four, eight, etc., and the small cells are built up in cube form and present the appearance of a cross-bound bale of goods.

The urine in which sarcinæ are found is chiefly alkaline, and in the sediment we find also calcium and triple phosphate. The evacuation of sarcinæ lasts for weeks, sometimes for months.

Fourth.—*Oidium lactis*.—This appears in the form of long cells, recognized by their granules being arranged at regular intervals. These occur not infrequently in the fermenting urine of diabetes.

Fifth.—*Penicillium glaucum*.—Besides the before-mentioned fungi spores of this plant may exist in the urine. In great part these appear as germs. Sometimes they are covered with a coating of fine urates, appearing furry and brown-red, or the development is further advanced, and the branching forms become extended and make up a network of interlacing fibres.

The spores for the evolution of all the forms of fungi mentioned develop outside of the bladder. This rule, however, has exceptions. The sarcinæ are always excreted with the urine from the bladder. Sometimes this may

be the case with bacteria, though this may be explained from the use of uncleansed sounds or catheters. Cases have come to our knowledge, though very rarely, where there was certainty of no instrument having been introduced previously into the bladder or urethra. It is very difficult to ascertain whether these forms of fungi have any influence on the reaction or fermentation of the urine. The small chain fungus appears not alone in alkaline urine, but in every case in which an albuminous substance becomes fetid or decomposed. We therefore find the same in the secretions of different ulcers, in ichor, and in cholera stools.

In this place we may mention, in passing, an indication which was formerly considered a characteristic sign of pregnancy. The name *kyesteine* was formerly given to the membrane which forms on the surface of long-standing urine of pregnant women, and which consists of an interlacing network in which calcium and triple phosphates, bacteria, and sometimes also animal organisms are imbedded. It forms, however, upon the urine of men, and has of late lost its significance.

196. *Extraneous objects*, consisting of atmospheric dust, fibres from all kinds of textures, starch granules, etc., will be found delineated in Roberts' work on "Urinary Diseases."

URINARY CALCULI

197. Are composed of one or more of the normal or abnormal materials which have been described as composing urinary sediments. They vary in size from that of sand nearly to that of the fist. They usually consist of a nucleus of a crystal of uric acid, a minute blood-clot, a tube-cast, rarely of some foreign substance which has been introduced into the urethra. Around this phosphates, carbonates, and other substances are deposited in concentric layers.

Uric acid is the usual constituent of vesical calculi; they are small and hard, unless mingled with phosphates, which is frequently the case.

Calcium oxalate calculi are very rough on the exterior, hence they have been called mulberry calculi.

The triple phosphate and calcium phosphate calculi are soft and readily crushed.

To examine a calculus.—Cut it through the middle by means of a fine saw. Its structure is thus exposed, and if the line of section has been well chosen, the nucleus is seen and its origin explained. The composition of each layer may then be determined by following the plan given for the examination of urinary sediments. As a preliminary the dry-heat test may be applied in each case.

ALPHABETICAL LIST OF SYMBOLS AND FORMULÆ.

Ag, silver.	Cu, copper.
Ag ₃ AsO ₃ , silver arsenite.	Cu ₂ C ₂ H ₃ O ₂ , cupric acetate.
AgCl, argentic chloride.	CuCO ₃ , cupric carbonate.
AgCy, argentic cyanide.	CuHAsO ₃ , { cupric arsenite.
AgNO ₃ , { argentic nitrate.	{ Paris green.
AgNO ₃ , { nitrate of silver.	Cu ₂ HO, cupric hydrate.
As, arsenic.	CuO, cupric oxide.
AsI ₃ , arsenious iodide.	Cu ₂ O, cuprous oxide.
As ₂ O ₃ , arsenious oxide.	CuS, copper sulphide.
As ₂ O ₅ , arsenic oxide.	CuSO ₄ .5H ₂ O, cupric sulphate.
As ₂ S ₂ , realgar.	Fe ₂ Cl ₆ , ferric chloride.
As ₂ S ₃ , orpiment.	Fe ₂ 6HO, ferric hydrate.
BaCl ₂ , barium chloride.	H, hydrogen.
C, carbon.	H ₃ AsO ₃ , arsenious acid.
C ₅ H ₄ N ₄ O ₃ , uric acid.	H ₃ AsO ₄ , arsenic acid.
C ₆ H ₁₀ O ₅ , starch.	HC ₂ H ₃ O ₂ , acetic acid.
C ₆ H ₁₂ O ₆ .H ₂ O, glucose, grape sugar.	H ₂ C ₃ H ₄ O ₃ , lactic acid.
C ₁₂ H ₂₄ O ₁₂ , lactose, milk sugar.	HCN or HCy, hydrocyanic acid.
C ₁₆ H ₁₈ N ₂ O ₃ , bilirubin.	H ₂ CO ₃ , carbonic acid.
C ₁₆ H ₁₈ N ₂ O ₄ , biliverdin.	H ₂ C ₂ O ₄ .2H ₂ O, oxalic acid.
C ₂₆ H ₄₄ O, cholesterin.	HCl, hydrochloric acid.
CO, carbon monoxide.	HNO ₃ , nitric acid.
CO ₂ , { carbon dioxide.	H ₂ O, water.
CO ₂ , { carbonic acid gas.	H ₂ S, hydrogen sulphide.
CON ₂ H ₄ , urea or carbamide.	H ₂ SO ₄ , sulphuric acid.
CaCl ₂ , calcium chloride.	Hg, mercury.
CaCO ₃ , calcium carbonate.	HgCl, mercurous chloride, calomel.
Ca ₂ HO, calcium hydrate.	HgCl ₂ , mercuric chloride, corrosive
CaSO ₄ , calcium sulphate.	sublimate.
Cl, chlorine.	HgI, mercurous iodide.

HgI_2 , mercuric iodide.	Na, sodium.
HgO , mercuric oxide.	Na_2CO_3 , sodium carbonate.
Hg_2O , mercurous oxide.	NaCl , sodium chloride.
HgS , mercuric sulphide.	NaHO , sodium hydrate.
Hg_2S , mercurous sulphide.	O, oxygen.
K, potassium.	P, phosphorus.
K_2CO_3 , potassium carbonate.	PH_3 , phosphide of hydrogen.
K_2CrO_4 , potassium chromate.	Pb, lead.
KCy, potassium cyanide.	PbCO_3 , white lead or carbonate.
KHO, potassium hydrate, caustic potash.	$\text{Pb}_2\text{C}_2\text{H}_3\text{O}_2$, lead acetate, sugar of lead.
KI, potassium iodide.	PbCl_2 , lead chloride.
$\text{K}(\text{SbO})\text{C}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$, tartar emetic.	PbCrO_4 , lead chromate.
N, nitrogen.	PbI_2 , lead iodide.
NH_3 , ammonia gas.	PbO, litharge.
NH_4Cl , ammonium chloride.	Pb_3O_4 , minium, red lead.
NH_4HO , ammonium hydrate.	PbS, lead sulphide, galena.
NH_4HS , ammonium sulphide.	PbSO_4 , lead sulphate.
NH_2HgCl , white precipitate.	Sb_2O_3 , antimony oxide.
	Sb_2S_3 , antimony sulphide.

ARRANGEMENT OF LABORATORY.

The apparatus, reagents, and chemicals required for the conduction of this course are as follows. The list also gives the location of each article, thus enabling the students and assistants to find it without unnecessary loss of time.

First.—The laboratory is provided with tables on which there are no permanent fixtures except Bunsen burners. Everything is stowed away in cases. There is, therefore, every opportunity to keep the tables clean. Each table accommodates two students seated opposite to each other. The students' places or seats are numbered in regular order.

Second.—Each student is provided with a rack containing apparatus and reagents in continued use, and bearing the number of his seat. The location of the articles in question is indicated in the list by the word *rack*.

Third.—For each table and for the pair of students occupying it, a box is provided which contains ninety-six small bottles in which the specimens and reagents mentioned in the list are placed. These are designated by numbers attached to the bottles, which correspond with those given in the list.

Fourth.—For each table a low box is provided in which burettes and other glass instruments are preserved. In the list these are referred to as *case*.

Fifth.—Cases are provided in which the rack and boxes, together with other pieces of apparatus, are stored by the students at the close of each day's work. The shelves of the cases bear numbers corresponding to the numbers of the seats occupied by the students.

Sixth.—A special case contains specimens which are rare or costly, and the instruments required for purposes of illustration. This is designated in the list as *museum*.

Seventh.—The general supplies of chemicals and glass-ware, and the special reagents which are used in quantity, are stored in stock cases; these are indicated by the term *stock*.

Name.	Location.
Acid acetic, glacial,	rack.
" hippuric,	museum.
" hydrochloric, pure,	rack.
" hydrocyanic,	No. 1.
" lactic,	" 2.
" nitric, pure,	rack.
" nitroso-nitric,	"
" oxalic,	No. 3.
" sulphuric, commercial,	rack.
" " standard sol.,	stock.
" " aromatic,	No. 4.
" uric,	" 5.
Albumen, dry,	" 6.
" solution,	stock.
Alcohol, commercial,	"
Amalgam,	No. 58.
Ammonium, chloride,	" 7.
" carbonate,	stock.
" hydrate, dilute,	rack.
" sulphide,	"
" urate,	museum.
Antimony,	No. 8.
" alloy (Britannia metal),	" 9.
" " (type metal),	" 10.
" oxide and sulphide (Kermes),	" 11.
" and potassium tartrate,	" 12.
" sulphide, native powdered,	" 13.
" " precipitated,	" 14.
" wine of,	" 15.
Aqua calcis,	stock.
" destillata,	"
Argentic, nitrate,	No. 16.
Arsenic,	" 17.
" bisulphide,	" 18.
" oxide,	" 19.
" tersulphide,	" 20.
Arsenious iodide,	" 21.
" oxide,	" 22.
" " two grains in tube,	museum.
" porcelainous,	"
" vitreous,	"
Arsenite, copper,	No. 23.
" potassium solution (Fowler),	" 24.
Balance,	museum.
Battery, Grove or Bunsen,	"
Battley's solution,	No. 25.
Barium, chloride,	" 26.
Bile-stains on linen,	" 27.
Bilirubin,	museum.
Biliverdin,	"
Blood-stains on linen,	No. 28.
Blow pipe,	case.
Blue pill,	No. 60.

Name.	Location.
Britannia metal,	No. 9.
Brunswick-green,	museum.
Bunsen burner or spirit-lamp,	case.
Burette, 25 c.c., .	"
Calcium carbonate,	No. 29.
" oxalate,	museum.
" oxide slackened,	stock.
" phosphate, precipitated,	No. 30.
" sulphate,	" 31.
" " solution,	stock.
Calculi, biliary, .	museum.
" gouty, .	"
" salivary,	"
" urinary,	"
Calomel, .	No. 67.
Capsule, porcelain, 2 ounces,	case.
Carbon dioxide apparatus,	museum.
" filters,	"
Casein,	"
Chalk,	No. 29.
Charcoal,	case.
Cholesterin,	museum.
Chrome-yellow,	No. 48.
Clarke's soap test,	stock.
Corks,	case.
Corrosive sublimate,	No. 63.
Copper foil slips, 1 in. $\times \frac{1}{16}$ thin,	" 32.
Cream tube,	case.
Cupric acetate,	No. 33.
" arsenite,	" 23.
" carbonate,	" 34.
" oxide,	" 35.
" sulphate, crystals,	" 36.
" " saturated solution.	rack.
" sulphide pyrites,	No. 37.
Cuprous oxide,	" 38.
Cylinder,	rack.
Cystine,	museum.
Dialyzer,	"
Dover's powder,	No. 73.
Epsom salt,	" 56.
Ether, sulphuric,	stock.
Fat or oil in emulsion,	"
Fehling's solution,	"
Ferric chloride,	No. 39.
Fibrin,	museum.
Files, rat-tail and triangular, 4 in.,	case.
Filters, 3 in. diameter,	"
Filtering paper slips, 1 in. \times 10 in.,	"
Flask, 1 ounce,	rack.

Name.	Location.
Fowler's solution,	No. 24.
Funnel,	rack.
Glucose,	No. 92.
Goulard's extract,	" 53.
Gratings,	museum
H ₂ S apparatus,	"
H ₂ S water bottle, 1 gallon,	stock.
Hemoglobin,	museum.
Hematin,	"
Hemin,	"
Hydrargyrum,	No. 57.
Indigo sulphate,	" 40.
Iron, oxide, dialyzed,	" 41.
" sulphide, for H ₂ S apparatus,	stock.
" wire, very fine, 1 in. long,	No. 42.
Isinglass,	" 43.
Kermes mineral,	" 11.
Lactose,	" 93.
Laudanum,	" 74.
Lavender comp. tinct.,	" 44.
Lead,	" 45.
" acetate,	" 46.
" carbonate,	" 47.
" chromate,	" 48.
" iodide,	" 49.
" oxide, 3 to 4 red,	" 50.
" pipe, tin lined,	" 51.
" protoxide,	" 52.
" subacetate, Goulard's,	" 53.
" white,	" 47.
Litharge,	" 52.
Litmus cubes,	" 54.
Magnesium, oxide,	" 55.
" sulphate,	" 56.
" " saturated sol.,	stock.
Measuring tube,	rack.
Mercury,	No. 57.
" alloy or amalgam,	" 58.
" with chalk,	" 59.
" mass (blue pill),	" 60.
" unguentum,	" 61.
Mercur-ammonium chloride,	" 62.
Mercuric chloride,	" 63.
" iodide,	" 64.
" oxide,	" 65.
" sulphide,	" 66.
Mercurous chloride,	" 67.
" iodide,	" 68.

Name.	Location.
Mercurous oxide,	No. 69.
" sulphide,	" 70.
Microscope,	museum.
Milk, condensed,	stock.
Millon's reagent,	"
Minium,	No. 50.
Morphia, sulphate solution,	" 71.
McMunn's elixir,	" 72.
Nessler's reagent,	stock.
Opium, alkaloid morphia sulph. sol.,	No. 71.
" elixir,	" 72.
" pulv., Dover's,	" 73.
" tinct.,	" 74.
" " camph.,	" 75.
Orpiment,	" 20.
Oxyhemoglobin,	museum.
Paris-green,	No. 23.
Paregoric,	" 75.
Phosphorus,	" 76.
" red,	" 77.
Pipette, simple,	rack.
" 10 c.c.,	case.
Pioskop,	"
Platinum foil spoon,	rack.
Polariscope,	museum.
Potassium, bichromate,	No. 78.
" chlorate,	" 79.
" cyanide,	" 80.
" ferrocyanide,	" 81.
" hydrate, sp. gr. 1,050,	rack.
" iodide,	No. 82.
" permanganate,	" 83.
" " test solution,	stock.
" and sodium tartrate,	"
Pouring rod,	rack.
Prisms,	museum.
Realgar,	No. 18.
Retort,	case.
Saccharose,	No. 91.
Schweinfurth's-green,	" 84.
Silver, nitrate,	" 16.
Slop jar,	case.
Sodium, carbonate,	No. 85.
" " standard sol.,	stock.
" chloride,	No. 86.
" " standard sol.,	stock.
" glycocholate,	museum.
" hydrate,	stock.
" hypochlorite,	"

Name.	Location.
Sodium, phosphate,	No. 87.
" " standard sol.,	stock.
" sulphate, "	"
" taurocholate,	museum.
" urate,	"
Sorrel, salt of,	No. 88.
Spectroscope,	museum.
Spirit lamp or Bunsen burner,	case.
Starch,	No. 89.
Strychnia, sulphate sol.,	" 90.
Sugar, cane,	" 91.
" grape,	" 92.
" milk,	" 93.
Tartar on teeth,	museum.
" emetic,	No. 12.
Tubes, test, small and large,	rack.
" sublimation,	case.
" thermometer, for jets,	"
Turmeric paper,	stock.
Type metal,	No. 10.
Tyrosine,	museum.
Urea,	No. 94.
Urinary sediments,	museum.
Urinometer and cylinder,	rack.
Vermilion,	No. 66.
Washing-bottle,	rack.
Watch-glasses,	"
Water bath,	case.
" distilled,	stock.
" hard,	"
" sewage,	"
White precipitate,	No. 62.
Wine glass,	rack.
Wood slips,	case.
Yeast-cake,	No. 95.
Zinc slips, $\frac{1}{2}$ wide and 1 in. long, thin,	" 96.

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